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GENERAL ELECTRIC CO BINGHAMTON N Y AIRCRAFT EQUIPMENT DIV F/8 1/3  
ELECTRONIC MASTER MONITOR AND ADVISORY DISPLAY SYSTEM. OPERATIO--ETC(U)

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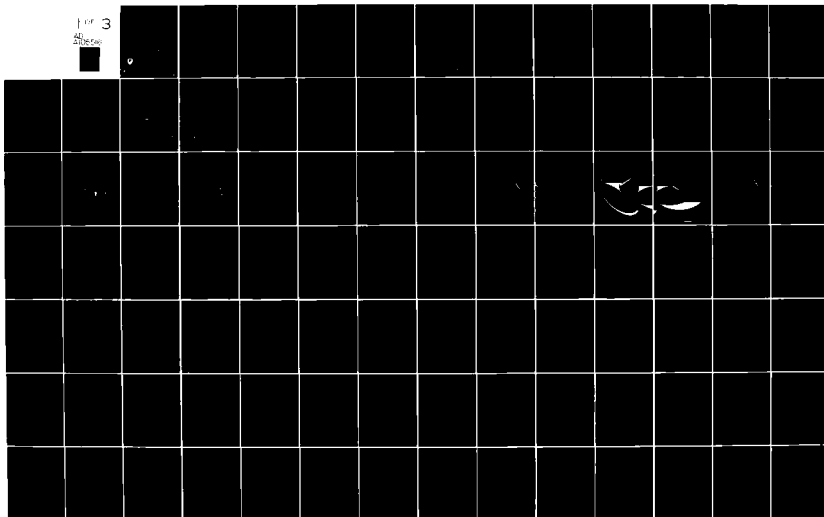
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Technical Report - 79-0270-2

ELECTRONIC MASTER MONITOR AND ADVISORY DISPLAY SYSTEM,  
OPERATIONAL FUNCTIONS REPORT

GENERAL ELECTRIC COMPANY  
AIRCRAFT EQUIPMENT DIVISION  
BINGHAMTON, NY 13902

OCTOBER 1980

SECOND INTERIM REPORT FOR PERIOD COVERING JUN 79 - OCT 80

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is being developed for use on U.S. Army helicopters to reduce crew workload by assuming responsibility for tasks associated with subsystem status monitoring. EMMADS will integrate all instrumentation normally dedicated to subsystem status monitoring (e.g. all pressures, temperatures, etc.) plus caution/warning/advisory indicators, into a computer controlled, solid state system. It will detect, analyze and provide emergency checklists for any faults that it is programmed to monitor for in these subsystems. This report represents a tying together of Tasks I & II to provide a baseline for defining the requirements of the feasibility demonstration hardware. In Task I, helicopters representing all operational helicopter categories (cargo, utility, scout, and attack) were identified and a signal analysis was done on each. While the EMMADS functions described in this report are applicable to all helicopter categories studied under Tasks I & II, specific examples used herein are all related to the CH-47C helicopter, since this aircraft had been selected as the basis for the EMMADS feasibility model.

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# GLOSSARY OF ABBREVIATIONS

AC	- Alternating Current
ACK	- Acknowledge
Aft Vert Thrust	- Aft Vertical Thrust Bearing
Brng	
AGB	- Accessory Gear Box
APU	- Auxiliary Power Unit
aux	- auxiliary
bst	- boost
°C	- degrees Celsius
Cond lever	- Condition lever
CRSE	- cruise
CTRL (or CTL)	- Control
DC	- Direct Current
ELEC	- Electrical
EMMADS	- Electronic Master Monitor and Advisory Display System
ENG	- Engine
exh	- exhaust
ext	- external
fwd	- forward
gen	- generator
HIT	- Health Indicator Test
hyd (or HYDR)	- hydraulic
lndg	- landing
MISC	- Miscellaneous
MLDS	- Multilegend Display Switch
N <sub>1</sub>	- engine gas producer speed
N <sub>2</sub>	- engine power turbine speed
norm	- normal
OVSP	- Overspeed

Accession For	
NTIS GRA&I	<input checked="checked" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By _____	
Distribution/ _____	
Availability Codes	
Dist	Avail and/or Special
A	

# GLOSSARY OF ABBREVIATIONS (CONT)

pos	- position
press (or prs)	- pressure
proc	- procedure
PTIT	- Power Turbine Inlet Temperature (same as TGT)
qty	- quantity
ref	- reference
rel	- release
rt	- right
RTU	- Remote Transmission Units
rpm	- revolutions per minute
SAS (or Stab Aug)	- Stability Augmentation System
STAT	- Status
sw	- switch
TBD	- To Be Determined
TBS	- To Be Specified
temp	- temperature
TGT	- Turbine Gas Temperature (same as PTIT)
X-feed	- cross feed
X-tie	- cross tie
XMSN	- transmission



## 1.0 SCOPE

This report describes the results of work done under Task I of contract No. DAAK 80-79-C-0270, to establish basic system operating requirements for an Electronic Master Monitor and Advisory Display System (EMMADS). This system is being developed for use on U.S. Army helicopters to reduce crew workload by assuming responsibility for tasks associated with subsystem status monitoring. EMMADS will integrate all instrumentation normally dedicated to subsystem status monitoring (e.g. all pressures, temperatures, etc.) plus caution/warning/advisory indicators, into a computer controlled, solid state system. It will detect, analyze and provide emergency checklists for any faults that it is programmed to monitor for in these subsystems.

While this report is being identified with Task I elements of the contract, it in fact also represents a tying together of Tasks I & II to provide a baseline for defining the requirements of the feasibility demonstration hardware of Task IV. In Task I, helicopters representing all operational helicopter categories (cargo, utility, scout and attack) were identified and a signal analysis was done on each. The results of the analyses for these aircraft (CH-47C, UH-60A, OH-58C and YAH-64 respectively) are in the form of Subsystem Parameter Data Lists, shown in Appendix 1. Under Task II, surveys of pilots were made to determine when and how information should be displayed (see EMMADS Human Engineering Summary Report). Coupling all of the above information together with a thorough understanding of flight operations, the Systems Engineering task of developing and implementing a coherent EMMADS operating philosophy was accomplished. This resulted in a system design based on the following underlying principles:

- a) The aircrew should be managers of the aircraft and as such must have information required for operation of the aircraft in minimum time and in the simplest possible form.

- b) The pilot in any flight situation must be able to fly the aircraft, i.e., he must retain or regain control of the aircraft. Any system that relates to this function (such as EMMADS) must enhance this capability and absolutely cannot interfere with it.
- c) During fault display operations, interactive manual inputs to EMMADS by the aircrew should be kept to a minimum.

These principles then form the core of the EMMADS operating philosophy. In this report, each element of the system's operation is presented and justified in terms of this philosophy.

While the EMMADS functions described in this report are applicable to all helicopter categories studied under Tasks I & II, specific examples used herein are all related to the CH-47C helicopter, since this aircraft had been selected as the basis for the EMMADS feasibility model.

## 2.0 APPLICABLE DOCUMENTS

Electronic Master Monitor and Advisory Display System: Human Factors Engineering Summary Report (ACS 12,385), R. McLane, Reliability and Human Factors Engineering, GE, Pittsfield, MA, Aug. 1980.

Subsystem Parameter Data Lists for CH-47C, UH-60A, OH-58C & YAH-64 (ACS 11,995) Appendix 1, General Electric Co., Binghamton, NY.

Technical Proposal for the Electronic Master Monitor and Advisory Display System - Part 1 (ACS 11,773-1), February 1979, General Electric Aircraft Equipment Division, Binghamton, NY.

TM 55-1520-227-10-2, Operator's Manual, Army Model CH-47C Helicopter, 23 August 1978.

Advanced Subsystem Status Monitor, Final Report, Contract DAAK51-78-C-0023, Sikorsky Aircraft, Div. of United Technologies Corp.

### 3.0 EMMADS CHARACTERISTICS

#### 3.1 System Overview

The block diagram shown in Figure 1 illustrates the basic EMMADS architecture as installed on an aircraft. The system utilizes a dual 1553B digital bus for data transmission. RTU's provide the interface required to digitally encode and place on the bus the aircraft sensor signals described in Appendix 1. Two digital display processors perform the monitoring and fault detection functions described in this report. They also determine the current formats to be displayed on the electroluminescent flat panels. Note that a separate processor is to be made usable at each crew station. A set of multilegend display switches (MLDS) associated with each display unit, provide the pilot with display control during all system operations. A keyboard is provided for data inputs to the system also. Provision for expanding system capabilities to include audio warning is also shown.

#### 3.2 System Functions

The EMMADS operational functions requirements are described in this report according to the system's primary and secondary functions.

The primary functions of an EMMADS are:

- a) Provide a continuous display of Rotor RPM, Torque, Flight Time Remaining (based on continuously monitored fuel consumption) and, when applicable, a countdown of remaining allowable time for operation of parameters within time limited ranges. It shall also display non-flight parameters to aircrew members upon request.
- b) Monitor aircraft subsystem parameters for possible

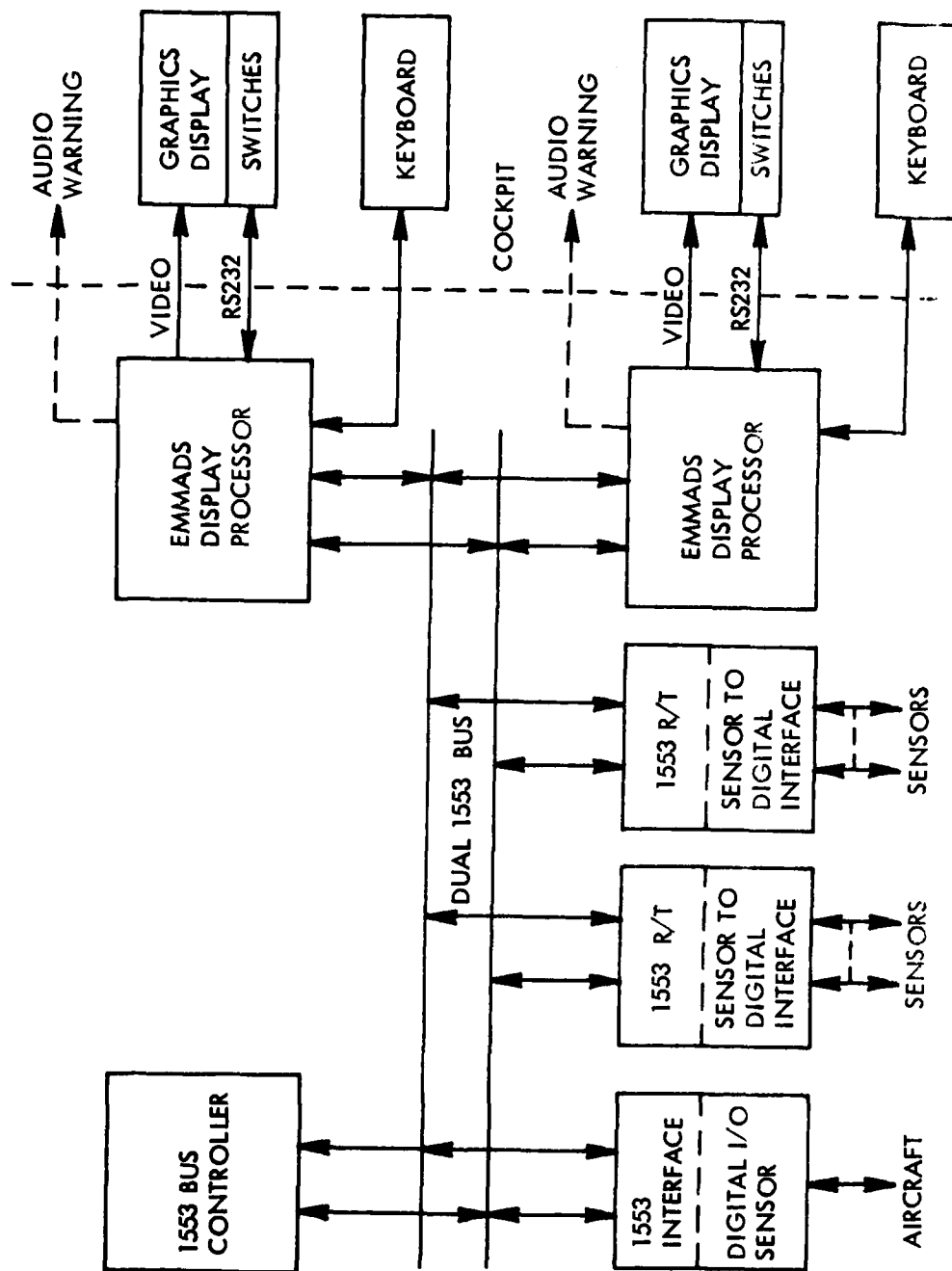


Figure 1. EMMADS Block Diagram

faults. This monitoring activity includes:

- 1) Correlation of current parameter status (value) with a particular limit or set of limits, the values of which may be functionally dependent on other parameter values. A parameter value that approaches, meets or exceeds an associated limit requires that the aircrew be notified.
  - 2) Correlation of the time rate of change of a parameter value with a maximum allowable rate of change based on manufacturer/procurement specifications or some experimentally established baseline. A rate of change that exceeds this maximum value requires notification of the aircrew.
- c) Detect composite faults resulting from multiple parameter excursions. Provide an unambiguous notification of the fault nature to the aircrew.
  - d) Display faults to the crew utilizing a flexible prioritization system and provide a means of rapidly communicating to EMMADS the pilot's observation of each fault.
  - e) Display recommended fault correction actions (emergency checklists) in response to aircrew requests.

The secondary functions of EMMADS include:

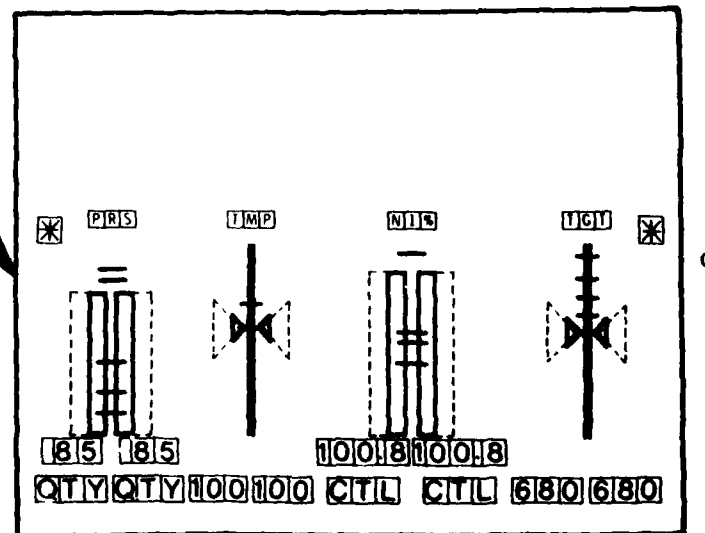
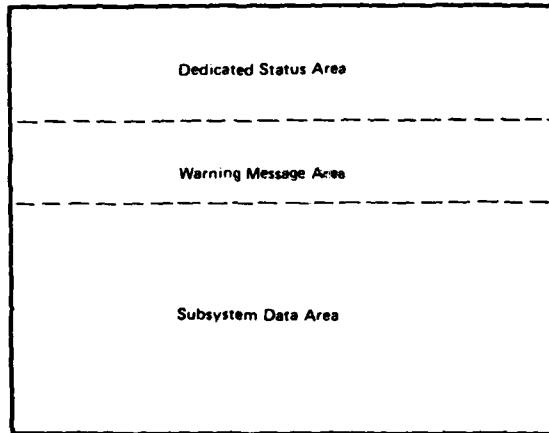
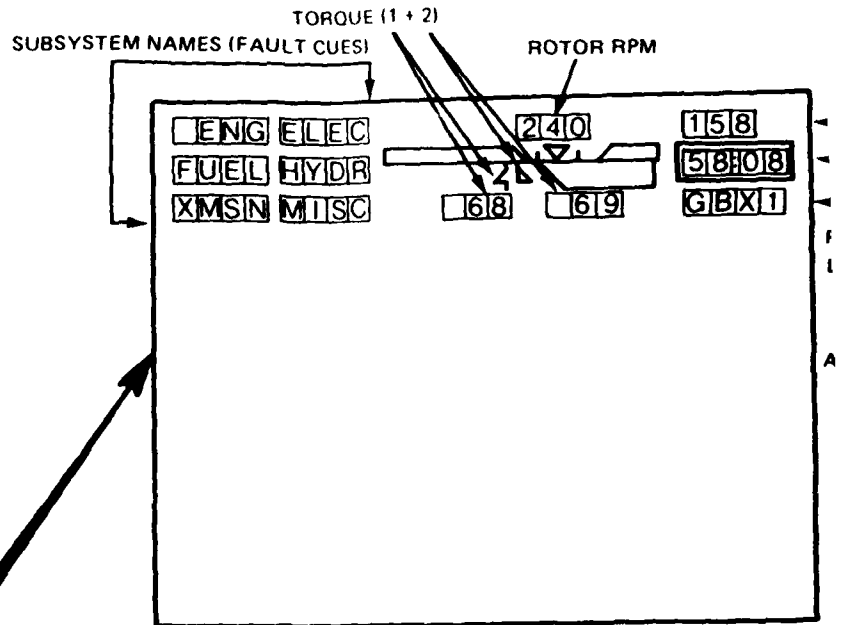
- a) The ability to display routine, interactive type checklists such as the Before Starting Engines, Starting Engines, Engine Ground Operation, Before Taxi, Taxiing Check, Before Takeoff, Cruise Check, Before Landing, After Landing and Engine Shutdown Checklists.

- b) Calculations to predict aircraft performance characteristics.
- c) Recording the occurrence of any faults, as required for post-flight maintenance analysis.

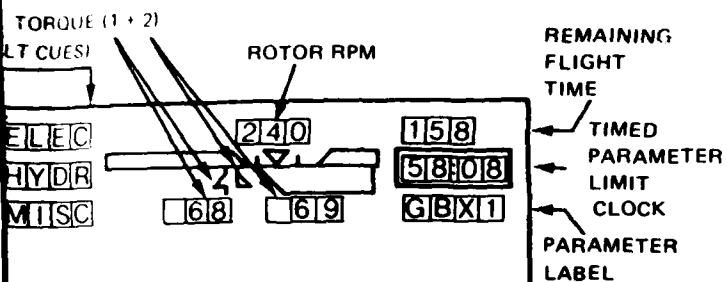
### 3.2.1 Primary Functions

#### 3.2.1.1 Display Areas

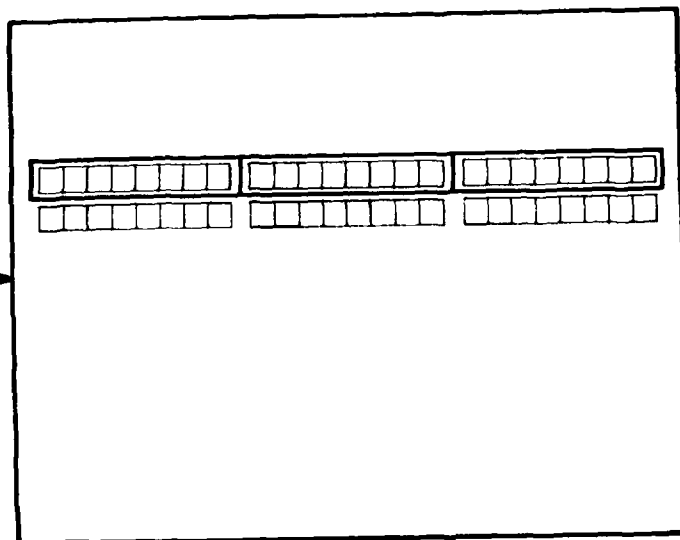
The EMMADS display is broken into three areas to facilitate efficient information transfer to the pilot. These are shown in Figure 2. (Note: In this and all other figures showing display formats, boxes are drawn around alphanumeric characters and may also be shown, empty, in other areas of the display. These are not part of the format, but are used to indicate the amount of space reserved for these characters.) The Dedicated Status Area is utilized for information requiring continuous display. This includes rotor rpm, torque and remaining flight time (in minutes). Other items shown in this area are connected with fault detection aspects of EMMADS. Once activated, they remain in this area, continuously displayed, until deactivated by other fault logic. Their operation is further described in Section 3.2.1.3. The Warning Message Area is reserved for displaying up to six messages of eight characters each, under conditions described in 3.2.1.3. The Subsystem Data Area is utilized for displaying parameters in the engine, fuel, transmission, electrical, hydraulic and miscellaneous subsystems, as well as emergency action checklists. (The engine subsystem is shown as an example in Figure 2.) The dotted lines shown with the bar (thermometer type) scales and pointer scales indicate these symbols can oversize to indicate a fault with that parameter. Oversized, hollow indicators are used to depict rate (trend) type faults, while oversized, filled-in symbols indicate a limit type fault. Special symbols for chips (\*) and other discrete type



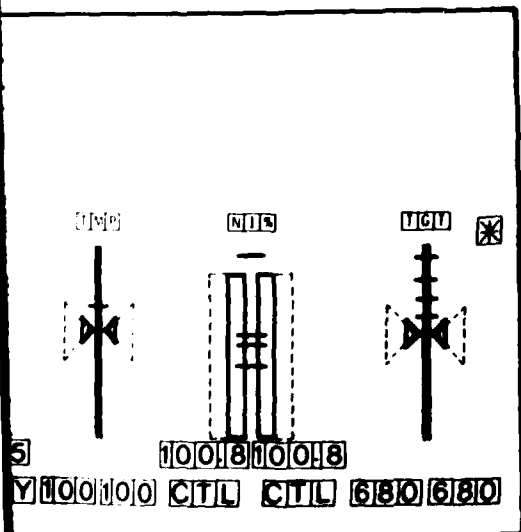




A



B



C

Figure 2. Display Unit Areas

2

faults are also used (e.g. QTY indicates low engine oil quantity and CTL indicates that an N1 control loop is energized). These and other faults are described in Sections 3.2.1.2 and 3.2.1.3.

#### 3.2.1.2 Fault Detection

The primary functions of fault detection and fault/ parameter display are to be performed on a continuous basis, i.e. they are accomplished independent of flight phase. The primary functions must be considered as preemptive of any secondary function. Sufficient time must be allocated to sample all parameters, update those currently being displayed, compute rates of change and compare these and current values to maximum rates of change or value limits, respectively, determine what faults exist, if any, and display them according to their priority. Adequate additional time per cycle should be available for secondary functions.

The test for fault conditions may be linked to flight phase. For example, in order to distinguish between an engine low side keep trim failure and a pilot commanded reduction to ground idle power, the EMMADS must be able to sense the position of the engine condition lever. While a commanded power reduction is normally a no-fault condition, during airborne operations the placement of an engine condition lever in a ground or idle position should be indicated to the pilot. It could be considered as a fault or as an advisory, but, in any event, it is a condition which warrants an information display to the pilot and constitutes a link with flight phase. The flight phase is useful in determining the operating mode for the measurement of parameter conditions, as part of the EMMADS primary function. Under various operating modes, parameter values (conditions) may or may not be abnormal, as shown in Appendix 1, Subsystem Parameter Data Lists.

There are two fault types which are handled by the EMMADS; single parameter faults and multiple parameter faults. A single parameter fault is detected by examining the characteristics of an individual parameter (signal) for:

- a. An out of tolerance value, or
- b. An out of tolerance rate of change (unfavorable trend).

A multiple parameter fault is one inferred by correlating the values of various related parameters. For example, to properly identify an engine failure, gas producer speed, turbine gas temperature, torque and engine oil pressure need to be compared. Parameter attributes, (values or rates of change) used by EMMADS as standards of comparison to detect either of these fault types, are set by the operating mode mentioned previously. The operating mode may be determined by some unrelated parameter or parameter group (e.g. when gross weight sets the normal rotor rpm limits).

Due to the large variations in the size and configuration of helicopters studied, the classification of faults and the related operating modes is aircraft specific. An example of a fault set, the Fault/Parameter Matrix for the CH-47C, is shown in Appendix 2. This matrix relates each fault to a set of parameters which either belong to a specific aircraft subsystem or are used to relate to a particular operating mode. For single parameter faults in this case, the Subsystem Parameter Data List, CH-47C, Appendix 1 illustrates the relationship between operating modes and various parameter conditions. The conditions on that list not classified as "normal" constitute fault conditions. For multiple parameter faults the operating modes and conditions are obtained from Chapter 9 of the Aircraft Operator's Manual.

### 3.2.1.3 Fault/Parameter Display

When a fault is detected, the pilot must be made aware of it. The system must allow the pilot to control what is on the display. At the same time he must be given information about new faults as they occur. A priority system must be established to allow the EMMADS to differentiate between faults of higher and lower relative importance.

In establishing such a fault priority structure, it is important to understand the information requirements when a fault occurs during a specific flight situation. The first task of the pilot when a fault occurs is to regain/maintain aircraft control. The second task is to take whatever action is necessary/possible to correct the condition. In no case should the accomplishment of the second task interfere with the first task. These fundamental considerations dictate that faults be divided into three major categories:

- a) Warnings - those faults which, if not immediately acted upon by the crew, will most likely seriously compromise the pilot's ability to control the aircraft and therefore could result in personal injury or loss of life.
- b) Cautions/Precautions - those faults which do not immediately jeopardize the safety of the crew or the ability to control the aircraft but which may result in equipment damage if not attended to. In addition, such faults, if allowed to continue without corrective action being taken, may precipitate one or more Warnings.
- c) Advisories - these are conditions (actually parameter states) the pilot should be made aware of. The

determination of whether or not these states are faults is left to the pilot, since the determination of the normal conditions depends on pilot judgement (e.g. Cargo Hook Open, Parking Brake ON, etc.)

Given the faults to be detected (such as those shown in the Fault/Parameter Matrix of Appendix 2) the first step in prioritization is simply to designate which faults fall into the Warning category. Then, by designating the conditions which are Advisories, the remaining fault conditions fall automatically into the Caution/Precaution category.

Such a fault partitioning scheme as applied to the CH-47C is shown in Table 1. Placing faults into the Warning category was based on the following considerations:

- a) A total loss of hydraulic pressure in the flight control systems makes it impossible to move the flight controls.
- b) Rotor rpm is directly related to aircraft lift, so loss of rotor rpm requires rapid pilot response.
- c) In a dual engine aircraft, given a choice of responding to a loss of engine speed control versus an engine failure, the pilot should first attend to the engine that is still operating.
- d) Faults in any subsystem which can rapidly precipitate loss of flight controls, loss of lift or loss of engine power are candidates for inclusion in the Warnings category. Each must be considered on an individual basis.

In assigning the specific numeric priorities contained in Table 1, the following additional considerations were taken into account:

TABLE 1. FAULT PRIORITIZATION FOR THE CH-47C HELICOPTER

<u>Fault</u>	<u>Subsystem Displayed</u>	<u>Priority</u>
<b>WARNINGS</b>		
Quill Shaft Failure	Hydraulic	1
Rotor RPM Limit (continuous display)	Engine	2
No. 1 Engine Beep Trim	Engine	3
High Side Failure		
No. 2 Engine Beep Trim	Engine	3
High Side Failure		
No. 1 Engine N <sub>2</sub> Sensing Failure	Engine	3
No. 2 Engine N <sub>2</sub> Sensing Failure	Engine	3
No. 1 Engine Beep Trim	Engine	4
Low Side Failure		
No. 2 Engine Beep Trim	Engine	4
Low Side Failure		
No. 1 & 2 Engines Failed	Engine	4
No. 1 Engine Failed	Engine	5
No. 2 Engine Failed	Engine	5
No. 1 Flight Control Hydraulic Press	Hydraulic	6
Low/Rate		
No. 2 Flight Control Hydraulic Press	Hydraulic	6
Low/Rate		
Eng. 1 & 2 Fuel Boost Press Limit	Fuel	7
(PA >6000')		
Eng. 1 Fuel Boost Press Limit	Fuel	8
(PA >6000')		
Eng. 2 Fuel Boost Press Limit	Fuel	8
(PA >6000')		
No. 1 and 2 SAS OFF	Miscellaneous	9
<b>CAUTIONS/PRECAUTIONS</b>		
Eng. 1 PTIT Limit/Rate (starting only)	Engine	10
Eng. 2 PTIT Limit/Rate (starting only)	Engine	10
Eng. 1 Torque Limit (continuous display)	Engine	10
Eng. 2 Torque Limit (continuous display)	Engine	10
Eng. 1 N <sub>1</sub> Limit	Engine	10
Eng. 2 N <sub>1</sub> Limit	Engine	10
Eng. 1 Oil Press Limit/Rate	Engine	10
Eng. 2 Oil Press Limit/Rate	Engine	10
Eng. 1 Oil Temp Limit/Rate	Engine	10
Eng. 2 Oil Temp Limit/Rate	Engine	10
Eng. 1 Chip Detected	Engine	10
Eng. 2 Chip Detected	Engine	10

TABLE 1.  
FLIGHT PRIORITIZATION FOR THE CH-47C HELICOPTER (cont'd)

<u>Fault</u>	<u>Subsystem Displayed</u>	<u>Priority</u>
CAUTIONS/PRECAUTION (cont'd)		
Eng. 1 Oil Level Limit	Engine	10
Eng. 2 Oil Level Limit	Engine	10
Eng. 1 N <sub>1</sub> Control Loop Energized	Engine	10
Eng. 2 N <sub>1</sub> Control Loop Energized	Engine	10
Fuel Qty-Left, Fwd Limit/Rate	Fuel	11
Fuel Qty-Left, Main Limit/Rate	Fuel	11
Fuel Qty-Left, Aft Limit/Rate	Fuel	11
Fuel Qty-Right, Fwd Limit/Rate	Fuel	11
Fuel Qty-Right, Main Limit/Rate	Fuel	11
Fuel Qty-Right, Aft Limit/Rate	Fuel	11
Eng. 1 Fuel Boost Press Limit (PA <6000')	Fuel	11
Eng. 2 Fuel Boost Press Limit (PA <6000')	Fuel	11
Fuel Boost Press, Left, Fwd Limit	Fuel	11
Fuel Boost Press, Left, Aft Limit	Fuel	11
Fuel Boost Press, Right, Fwd Limit	Fuel	11
Fuel Boost Press, Right, Aft Limit	Fuel	11
Eng. 1 Fuel Flow High	Fuel	11
Eng. 2 Fuel Flow High	Fuel	11
Eng. 1 Xmsn Oil Press Limit/Rate	Powertrain	12
Eng. 2 Xmsn Oil Press Limit/Rate	Powertrain	12
Combining Xmsn Oil Press Limit/Rate	Powertrain	12
Fwd Xmsn Oil Press Limit/Rate	Powertrain	12
Aft Xmsn Oil Press Limit/Rate	Powertrain	12
Eng. 1 Xmsn Oil Temp Limit/Rate	Powertrain	12
Eng. 2 Xmsn Oil Temp Limit/Rate	Powertrain	12
Combining Xmsn Oil Temp Limit/Rate	Powertrain	12
Fwd Xmsn Oil Temp Limit/Rate	Powertrain	12
Aft Xmsn Oil Temp Limit/Rate	Powertrain	12
Combining Xmsn Chip Detected	Powertrain	12
Fwd Xmsn Chip Detected	Powertrain	12
Aft Xmsn Chip Detected	Powertrain	12
Aft Thrust Bearing Chip Detected	Powertrain	12
No. 1 Generator Load Limit	Electrical	13
No. 2 Generator Load Limit	Electrical	13
No. 1 & 2 Generators Failed	Electrical	13
No. 1 Rectifier Load Limit	Electrical	13
No. 2 Rectifier Load Limit	Electrical	13
No. 1 & 2 Rectifiers Failed	Electrical	13
AC Bus X-Tie Failure	Electrical	13
DC Bus X-Tie Failure	Electrical	13

TABLE 1  
FAULT PRIORITIZATION FOR THE CH-47C HELICOPTER (Cont'd)

<u>Fault</u>	<u>Subsystem Displayed</u>	<u>Priority</u>
CAUTIONS/PRECAUTIONS (Cont'd)		
No. 1 Flight Control Hydraulic Press High	Hydraulic	14
No. 2 Flight Control Hydraulic Press High	Hydraulic	14
Utility Hydraulic Press Limit/Rate	Hydraulic	14
Utility Hydraulic Temp Limit	Hydraulic	14
APU Accumulator Press Limit	Hydraulic	14
No. 1 SAS OFF	Miscellaneous	15
No. 2 SAS OFF	Miscellaneous	15
Fwd Cyclic Trim Actuator Position Limit	Miscellaneous	15
Aft Cyclic Trim Actuator Position Limit	Miscellaneous	15
Right Aft Landing Gear Phase Limit	Miscellaneous	15
Heater Output Temperature Limit	Miscellaneous	15
ADVISORIES		
AC External Power Connected	Electrical	16
DC External Power Connected	Electrical	16
Parking Brake On/Off	Miscellaneous	16
Cargo Hook Open/Closed	Miscellaneous	16
APU On/Off	Miscellaneous	16



- a) If similar faults can occur in more than one area of the same subsystem, then there is no difference in their priority unless all such faults occur in combination (e.g., a flameout in one engine is just as serious as a flameout in the other engine, but a flameout in both engines is more serious).
- b) Faults that are mutually exclusive can be assigned the same level of priority. For example, a given engine cannot simultaneously experience a beep trim high side and low side failure.
- c) In assigning general priorities within the Caution/Precaution category, it is more reasonable to assign priorities based on the subsystems wherein the faults reside, as opposed to assigning priorities on an individual basis (except in the case of those faults in the "Miscellaneous" subsystem).

This last point may not seem realistic until one realizes that all of the immediate action (Warning category) faults are removed first and the remaining faults (Not Advisories) all require a pilot reaction of about the same level of urgency. Given that the pilot is going to acknowledge all faults in a reasonably short time and that he will be alerted when any fault occurs, the prioritization according to subsystem importance is the simplest and most logical procedure to follow.

Highest on the list of Cautions/Precautions should be the Engine subsystem since the engines provide the power to stay aloft. This is followed by the Fuel subsystem because it directly affects the ability of the engines to continue operating. Next comes the Powertrain subsystem (minus the continuously displayed rotor rpm) since it is probable that there will be a larger time span within which to react to a fault in this subsystem as opposed to faults

in the two subsystems just listed. (For example, transmissions have been designed to run as long as 30 minutes with no oil in the sump.) Following this would be the Electrical and Hydraulic subsystems, respectively. (Keep in mind that major flight control hydraulic faults are already included in the Warning category.) Finally, all remaining faults are prioritized according to estimated relative urgency in the Miscellaneous subsystem. At this time, no further prioritization has been deemed necessary. It is possible that future considerations may indicate that some faults in one subsystem should really have the same priority as faults in another subsystem, insofar as the urgency of the desired crew reaction is concerned. Determinations of this type can be made only after a prototype system has been used to gather specific aircrew recommendations under suitable test conditions.

The final subcategory, which has not yet been addressed, is that of Advisories. When an advisory level condition occurs, it is generally a state change of a discrete sensor. It has the lowest display priority. Hence advisory state changes will be displayed only if no faults take display priority. In the case of the CH-47C used as an example in Table 1, there are five advisory conditions currently identified: AC External Power, DC External Power, Parking Brake Status, Cargo Hook Status and APU On/Off Status.

Given the preceeding discussion as background, the system operation with regards to fault detection and display may now be discussed. As previously described, with no faults active, the display is clear except for Rotor rpm, Torque and Remaining

Flight Time, as shown in Figure 3. If a fault is detected, the following events take place:

- a) The aircraft Master Caution light is illuminated by the EMMADS computer.
- b) EMMADS determines the highest priority fault using the priority structure of Table 1 and displays the raw data of the subsystem related to that fault in the Subsystem Data Area. Figure 4 shows an example of this for the case of a failure of the number 2 engine. Note that the out of tolerance parameters are indicated by the use of oversized symbology. The fact that the symbols are filled in indicates that an operational limit has been exceeded. Note also that if other faults existed in the same subsystem, they would likewise appear even though they might be of lower priority than the fault which brought about the display of that subsystem. The symbols are flashing because they are part of a fault which is not yet acknowledged. Also, the subsystem name "ENG" in the upper left of the Dedicated Status Area is flashing because there is an unacknowledged fault in that subsystem. Note that the MLDS previously labeled "ENG DATA" now reads "ENG ACK" and the right most switch now reads "WARN ACK".

When a Warning is detected, an appropriate message is displayed in the Warning Message Area. (In the case of the example in Figure 4, the engine failure results in the message ENG 2 OUT being displayed.) A box around the message(s) indicates the highest priority warning(s) displayed. These highest priority warning messages are located in the top row of the Warning Message Area. The messages have positional significance: left and right of center if they pertain to engine or system numbers 1 & 2 respectively or centered when no such symmetry considerations exist (e.g., rotor rpm).

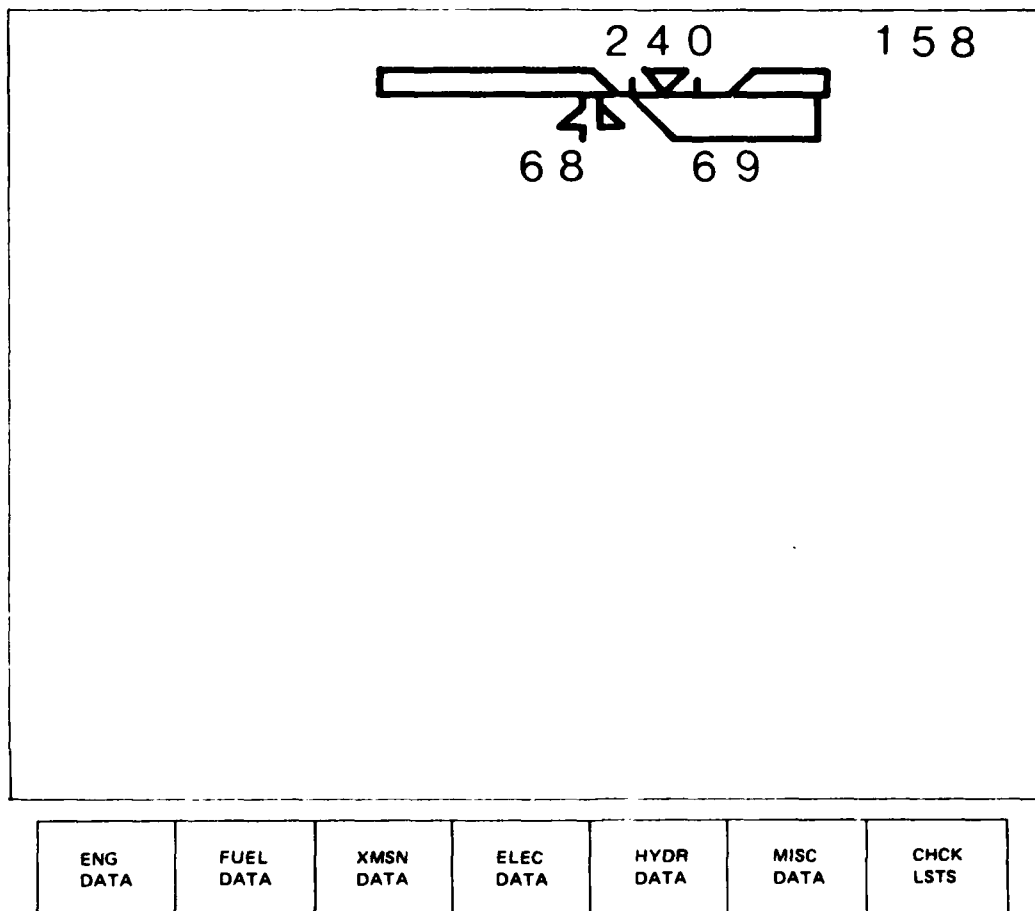


Figure 3. Sample Display Format - No Faults

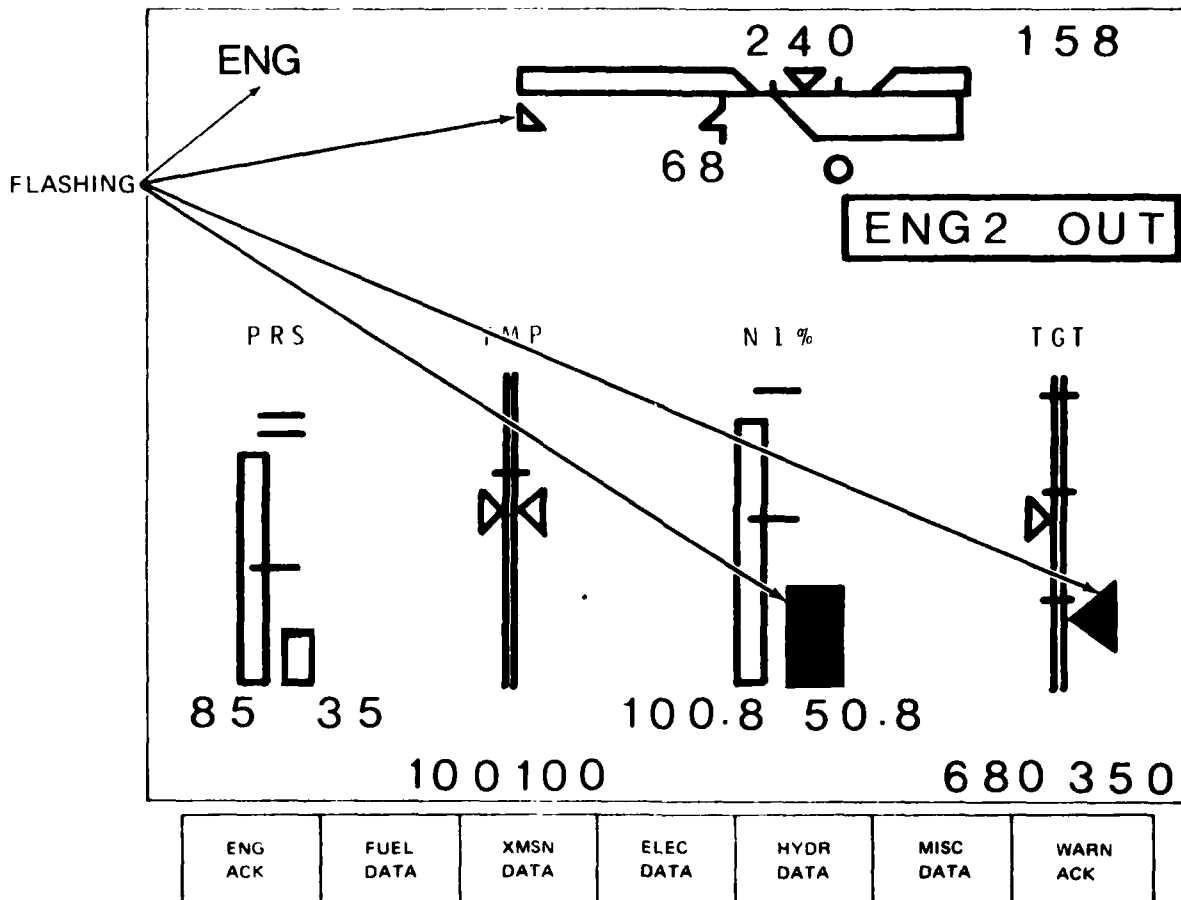


Figure 4. Sample Display Format - Fault Detected

- c) The pilot must manually acknowledge that he has reviewed the faults in the displayed subsystem, using a cyclic mounted acknowledge switch or the MLDS labeled "ENG ACK" or "WARN ACK" as described in Section 3.2.1.4. Actuation of either of these switches acknowledges the highest priority Warning and results in the appropriate emergency procedures checklist being placed on the display together with or instead of the subsystem data. Figure 5 illustrates this transition for the example started in Figures 2 and 3. This first actuation of the acknowledge switch also extinguishes the Master Caution Light.
- d) The pilot notifies EMMADS of checklist completion using the acknowledge function. In the example used in Figure 5, no other faults existed and the failed engine checklist has been acknowledged so the display format would change to that shown in Figure 6. Note that the word ENG is now steadily illuminated in the upper left hand corner, indicating that the engine fault, although acknowledged, still exists.

An important distinction should be made regarding acknowledgement of Warnings versus other faults. The acknowledge (ACK) switch on the flight control will acknowledge Warnings separately. Once all Warnings are acknowledged, all remaining faults are acknowledged by subsystem. Thus, an engine display with two or more "non-Warning" type faults will be cleared by actuating the ACK switch once. This allows the pilot to rapidly review all faults while keeping his hands on the flight controls.

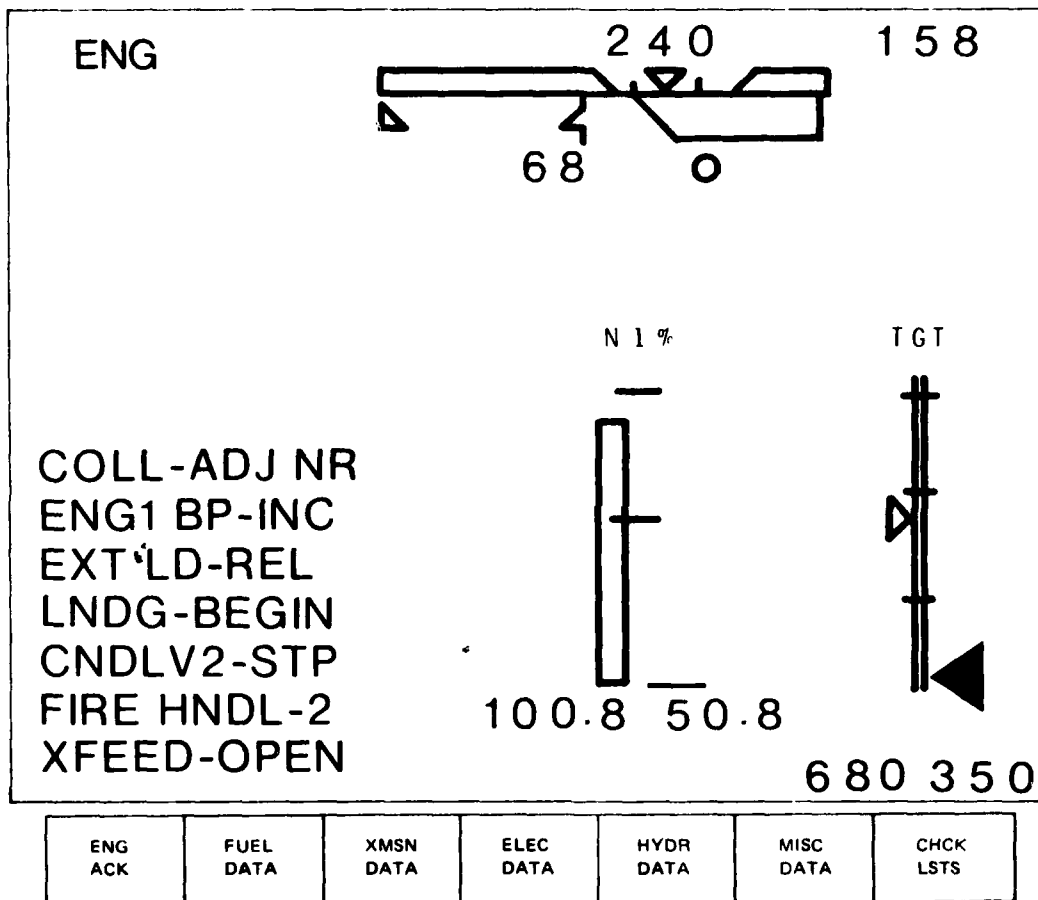


Figure 5. Sample Display Format - Warning Acknowledged, Checklist Displayed

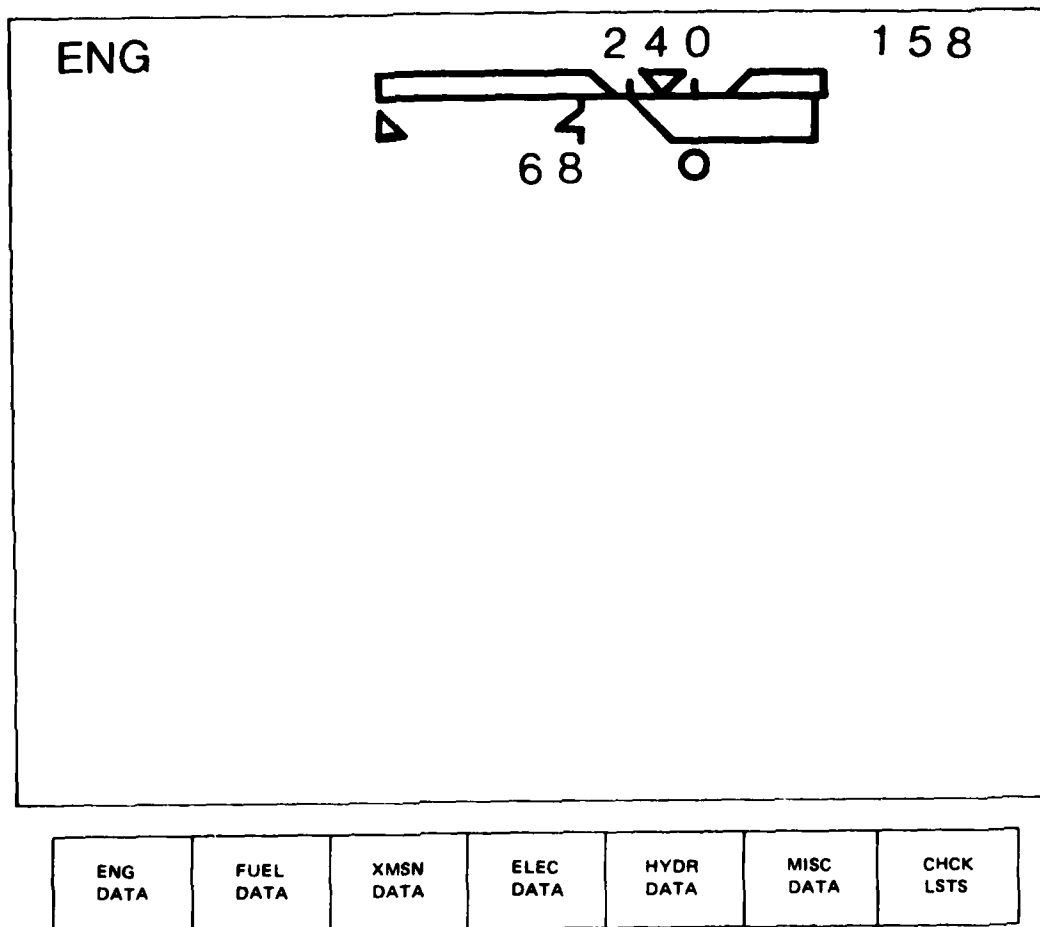


Figure 6. Sample Display Format - Fault Acknowledged, Checklist Completed



The previous example did not address the question of what happens when a fault of lower priority is displaced by a high priority fault. This can occur in two ways: the lower priority fault occurs first and then the high priority fault masks it or the low priority fault occurs while the pilot is still dealing with the high priority fault. In either case, the name of the subsystem in which the low priority fault resides will appear, flashing, in the top left of the Dedicated Status Area, to indicate that an active fault(s), not yet acknowledged, exists in that subsystem.

Another element of the fault display not yet discussed has to do with the amount of time remaining when a parameter is operating in a time limited range. This information also appears in the Dedicated Status Area, as a Timed Parameter Limit Clock located under the Remaining Flight Time indicator. The logic governing the use of this Timed Parameter Limit Clock dictates that its display requires a priority system different from that employed for fault display. From both an operational and a human factors standpoint, the major considerations in establishing such a priority system are:

- a) The pilot is capable of taking action on only one countdown at a time, and
- b) The pilot will concentrate on the countdown with the least time to go.

Based on this, it is logical to display only one countdown at a time; the one with the least time remaining. However, there may be some parameters with timed operating ranges the pilot can control directly and others he cannot. In this case, the display priority for remaining time is in two major divisions, with actively controlled parameters having priority over those that are not. Within each of these two categories, the least time remaining criteria applies for display priority.

As an example of the total amount of information which must be processed for this mode the parameters on the CH-47C that have timed operating limits include Rotor RPM, Torque, PTIT and Engine Gearbox Oil Temperature. (See Subsystem Parameter Data List, CH-4C, Appendix 1.) Thus, the first three are placed in the higher (actively controlled) display category, and their countdowns have priority over that of the Engine Gearbox Oil Temperature.

#### 3.2.1.4 Multilegend Display Switch (MLDS) Operation

The aircrew has the capability of selecting raw data for display, by subsystem, using a series of MLDS's located adjacent to the display panel. Several factors governing their operation should be noted:

- a) Whenever the format on the EMMADS display is not one seen under "normal" operating conditions (i.e., only the Dedicated Status Area appears) the right most switch marked "STAT ONLY" is available to allow the pilot to return the display back to the Dedicated Status Area only.
- b) This same switch is used to modify the operating mode of all the other switches, by changing their legends simultaneously. This results in three major levels of switch operation: Data/Emergency Procedures, Routine Checklists and Performance Calculations.
- c) Switch actuation will change the display only if there is no conflict with the fault detection and display algorithms, which have priority.

There are two modes of operation possible for the MLDS's Manual Display Command operations and Fault Related Operations.

#### 3.2.1.4.1 MLDS Operations - Manual Display Command

Under normal conditions, with no faults displayed, the seven MLDS's immediately below the display bear the legends shown in of Figure 7a. Actuation of any one of the first six switches places the data for the selected subsystem on the EMMADS display and changes the legend of the depressed switch and the right-most switch as shown in the figure. The set of MLDS legends in Figure 7a then represents the system being in the Subsystem Information Level. The result of depressing a switch with a "PROC" label is that the subsystem data is replaced by the first page of the highest priority emergency procedures checklist applicable to that subsystem. Successive actuations of that switch will result in the sequential display of all such checklists remaining. Depressing the "PROC" switch one more time when the last checklist is on the screen clears the display except for the Dedicated Status Area and returns all switch legends to the original set shown in Figure 7a. For Figures 7b-7g, depressing any switch other than the one with the "PROC" or the "STAT ONLY" legends will have no effect.

The legends may be changed simultaneously to the Routine Checklist Level by depressing the "CHCK LSTS" switch, as shown in Figure 8. This also clears the display except for the Dedicated Status Area. The six left-most switches now provide for selection of various routine checklists, to be displayed in the combined Warning Message and Subsystem Data Areas. As shown in Figure 9, depressing any of the first six switches changes the legend of that switch and the right-most switch, as well as presenting the first page of that checklist on the display. For example, in Figure 9c, the Normal Starting Engines checklist is selected ("NORM STRT" depressed). Depressing that same switch again (now labeled "MTF STRT" in the example shown) calls up a different checklist for display and would change that switch legend back to the previous one ("NORM STRT"). All of the first six switches

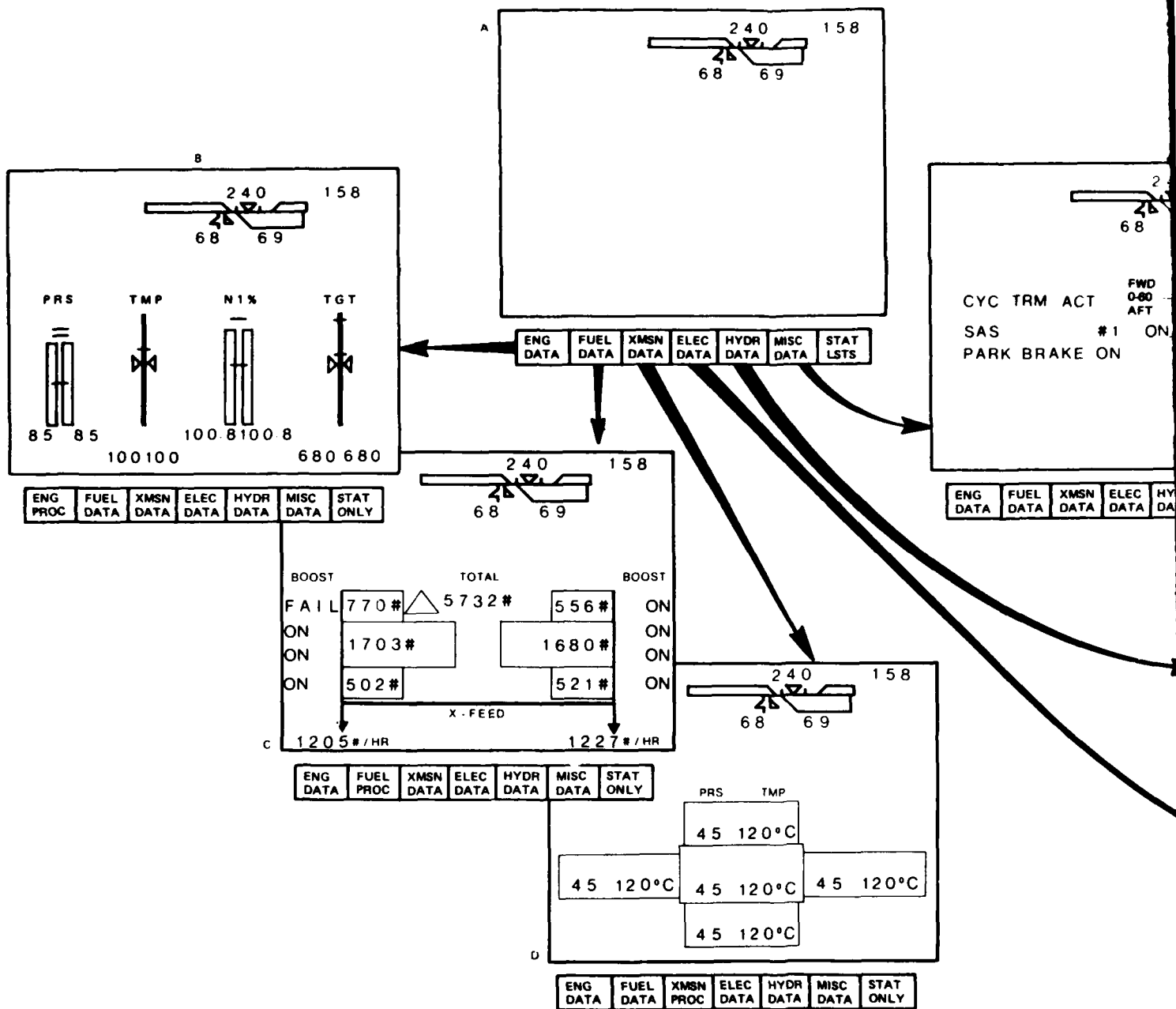


Figure 7

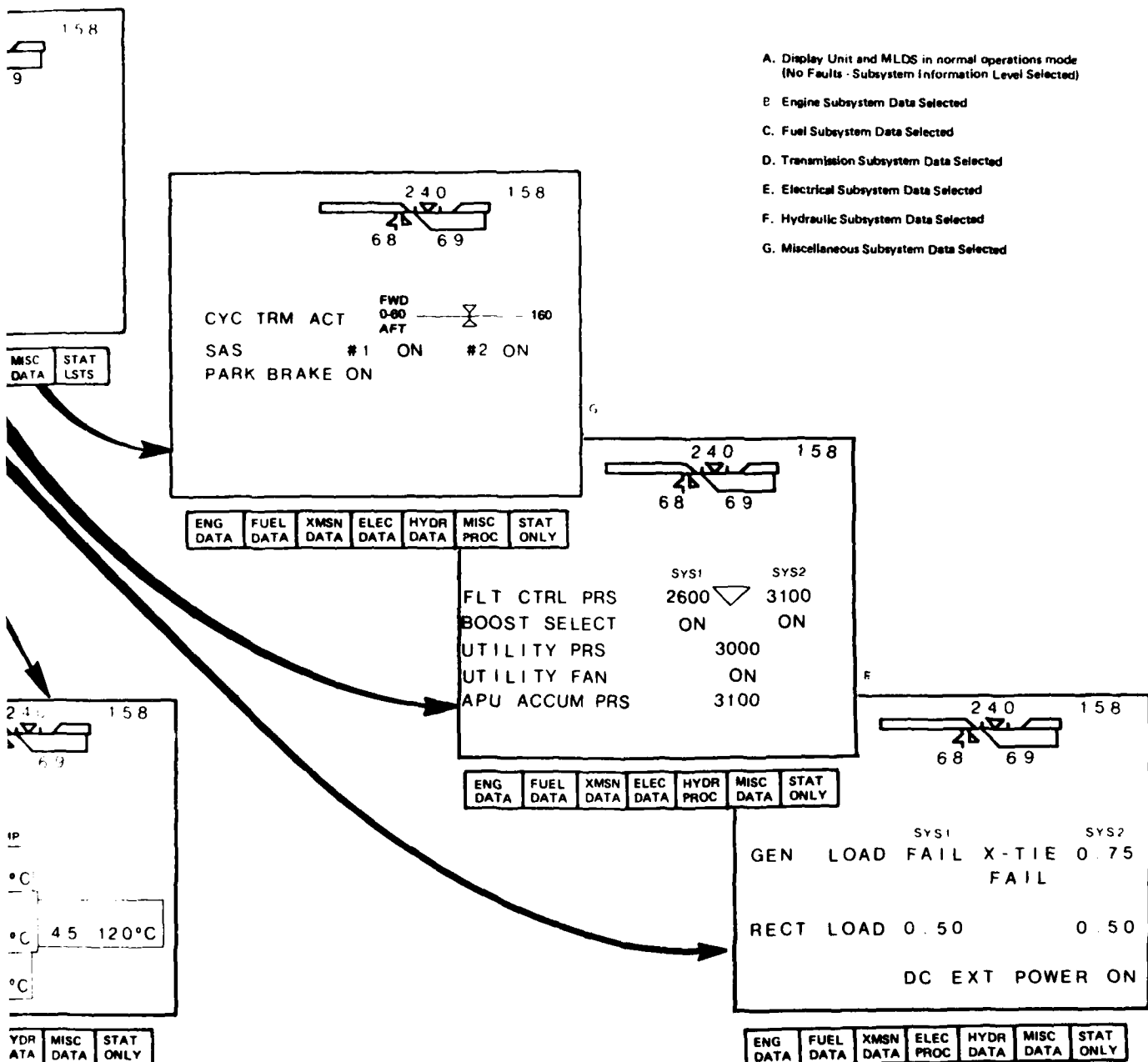
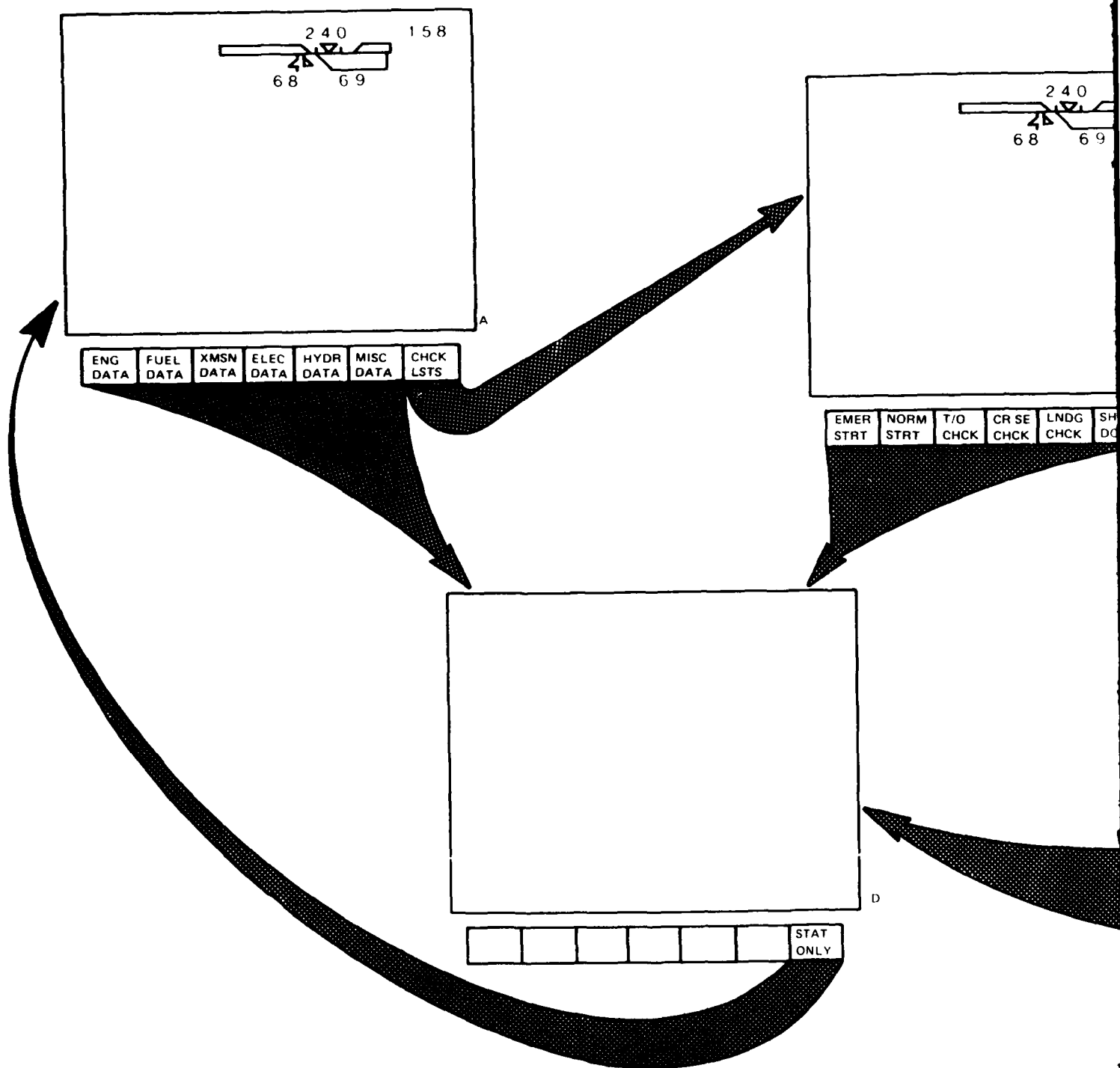
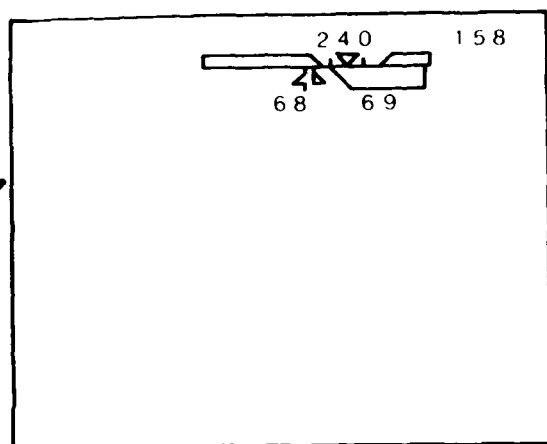


Figure 7. MLDS Functions - Subsystem Information Level





B

A. Subsystem Information Level

(Note that only Dedicated Status Area information is on the Display Unit)

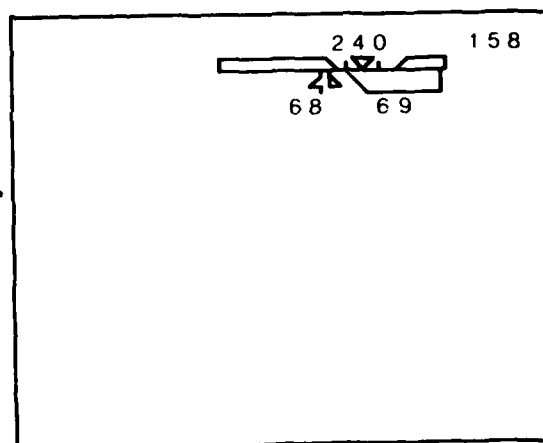
B. Routine Checklist Level

(Note that only Dedicated Status Area information is on the Display Unit)

C. Performance Calculation Level

(Note that only Dedicated Status Area information is on the Display Unit)

D. The "STAT ONLY" legend appears on the last switch whenever any of the indicated switches are depressed. The information on the Display Unit and the other switch legends are discussed in the text.



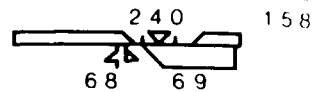
C



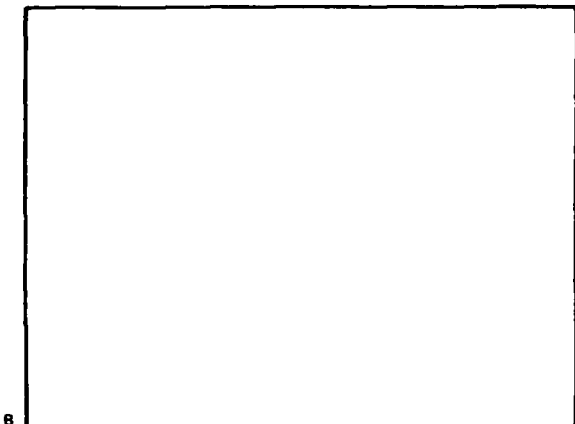
STAT  
ONLY

Figure 8. MLDS Operation -  
Format Level Selection

A



EMER STRT	NORM STRT	T/O CHCK	CRSE CHCK	LNDG CHCK	SHUT DOWN	PERF CALC
--------------	--------------	-------------	--------------	--------------	--------------	--------------



B

EMER STRT	NORM STRT	T/O CHCK	CRSE CHCK	LNDG CHCK	SHUT DOWN	STAT ONLY	APU START												
							HOME - CHECK												<input checked="" type="checkbox"/>
							XFD VLV LTS - TEST												<input checked="" type="checkbox"/>
							FIRE GUARD - POST												<input checked="" type="checkbox"/>
							MASTER CAUT LT - TEST												<input checked="" type="checkbox"/>
							APU OIL PRS LT - TEST												<input checked="" type="checkbox"/>
							APU STRT SW												<input checked="" type="checkbox"/>
							GND - APU - AGB SW												<input checked="" type="checkbox"/>
							APU STRT SW												<input checked="" type="checkbox"/>
							GEN 1 & 2 CTRL SWS												<input checked="" type="checkbox"/>
							EXT PWR - DISCONNECT												<input checked="" type="checkbox"/>
							FLT CTRLS - POS CHECK												<input checked="" type="checkbox"/>

C

EMER STRT	MTF STRT	T/O CHCK	CRSE CHCK	LNDG CHCK	SHUT DOWN	STAT ONLY
--------------	-------------	-------------	--------------	--------------	--------------	--------------

D

EMER STRT	NORM STRT	MTF T/O	CRSE CHCK	LNDG CHCK	SHUT DOWN	STAT ONLY
--------------	--------------	------------	--------------	--------------	--------------	--------------

1



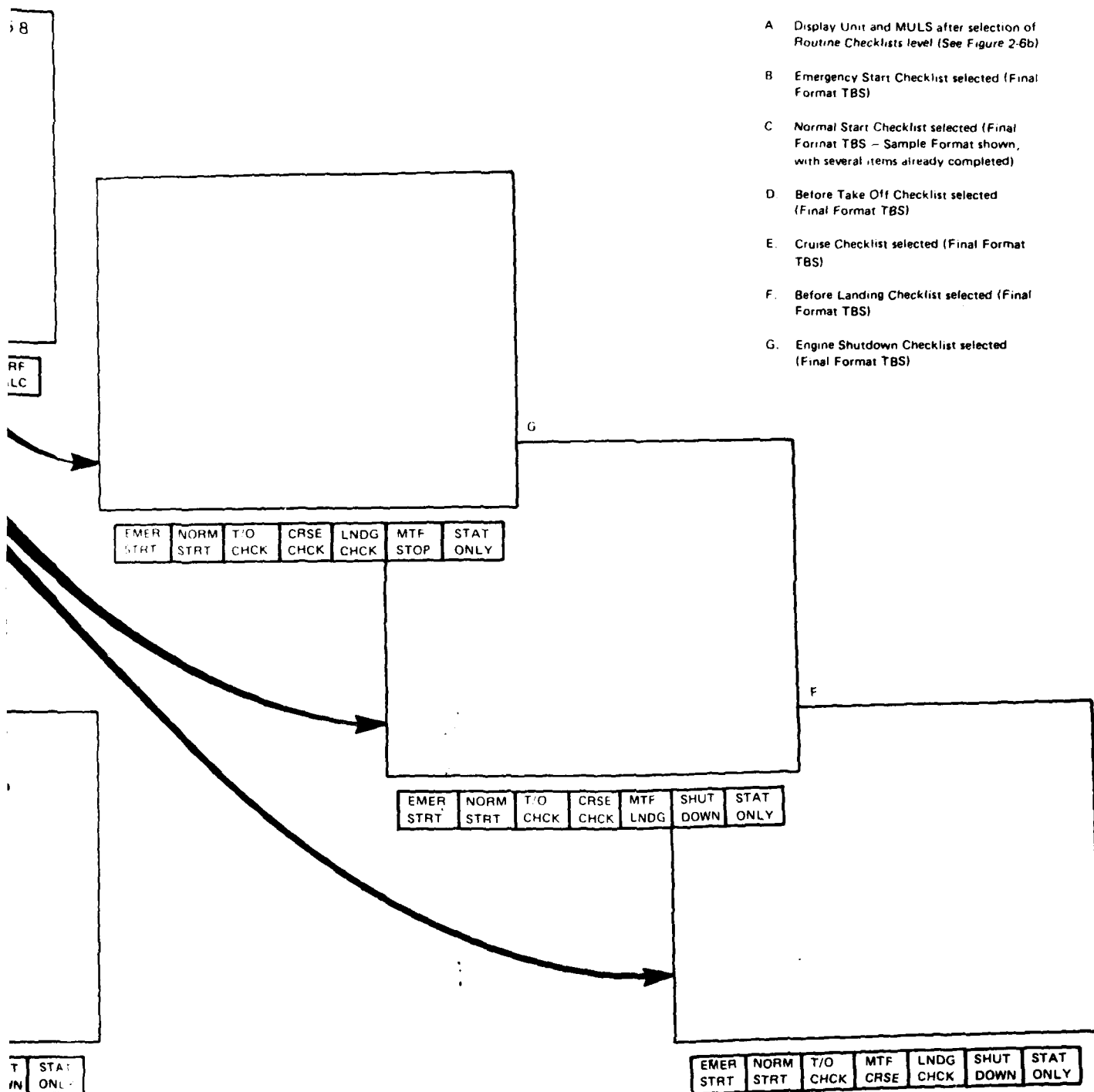


Figure 9. MLDS Operation -  
Routine Checklists Level

(except "EMER STRT") operate in a similar manner, as shown.

Depressing the switch labeled "PERF CALC" changes the switch legends as shown in Figure 8c while simultaneously clearing the display, except for the Dedicated Status Area. This figure shows that depressing the 7 "LMTS SUMM" switch changes the legend of that switch only. This is true of all the other switches as well, with no change in the legends of the first six switches. The "LMTS SUMM" switch displays the Limits Summary data which is used for post-flight maintenance playback of faults. Other switches select various performance calculations for display (see Section 3.2.2.2)

The only function not yet described is that of the "STAT ONLY" switch. Figure 8d shows that no matter what legends appear on the first six switches, depressing the "STAT ONLY" switch always returns the switch legends to those of the Subsystem Information Level and clears the display except for the Dedicated Status Area.

#### 3.2.1.4.2 MLDS Operations - Fault Related

In the case where a fault is being displayed, the switch normally associated with the displayed subsystem has its legend changed to "XXXX ACK", where "XXXX" represents the subsystem name. This switch function now exactly duplicates that of the ACK switch on the flight control. The switch legends revert back to those of Figure 7a when all faults/emergency procedure checklists are acknowledged. If Warning Messages are displayed, the legend of the right-most switch will also be changed to "WARN ACK". The pilot has the option of using this switch to simultaneously acknowledge all Warnings, as opposed to acknowledging each one separately. This would also bypass the automatic display of each emergency procedures checklist associated with those Warnings. These checklists would then be selectable later using the "XXXX

PROC" switches. Once the "WARN ACK" switch is depressed, its legend reverts to "CHCK LSTS".

The switches described above are the only ones actually changed when faults are being displayed. All others retain their original legends but will do nothing if depressed.

A description of the switch legends is included in Table 2.

#### 3.2.1.5 Emergency Action Checklists

The display of emergency action checklists is accomplished through two mechanisms:

- a) Checklists associated with Warning type faults are automatically displayed after an acknowledge switch other than "WARN ACK" is actuated,
- b) All checklists may be accessed using the releghendable switches marked "PROC" as described in Section 3.2.1.4.

After the acknowledgement of an individual Warning, the associated emergency action checklist is displayed, utilizing formats (TBS) supplied by Human Factors Engineering. The checklists are manually acknowledged and are completed item by item in the same manner as the routine interactive checklists discussed later in Section 3.2.2.1. Upon completion of a checklist, the subsystem for the next highest priority Warning appears. The Warning Message is boxed in (see Figure 3) and it's checklist may then be displayed in a like manner. If there are no more Warnings, the subsystem with the next highest priority fault(s) is displayed. To access emergency checklists in a given subsystem, depressing the "PROC" switch (after all faults have been acknowledged) changes the "PROC" to "ACK" and causes EMMADS to display the checklist for the highest priority, active fault

TABLE 2. SWITCH LEGEND DESCRIPTIONS

<u>Legend</u>	<u>Description</u>
(XXXX) DATA	Raw sensor data is displayed for the subsystems designated by "XXXX" - i.e., the Engine, Fuel, Transmission, Electrical, Hydraulic and Miscellaneous subsystems. (Formats other than Engine Subsystem TBS)
CHCK LSTS	Checklists switch legends will be selected
(XXXX) PROC	Emergency procedures (checklists) are displayed for the subsystems designated by "XXXX" (as described above for DATA legends. Formats TBS)
STAT ONLY	Display cleared except for the Dedicated Status Area (see Figure 8).
EMER STRT	Emergency Start checklist will be displayed. (TBS)
NORM STRT	Normal Start checklist will be displayed. (see Appendix 4)
T/O CHCK	Before Takeoff checklist will be displayed. (see Appendix 4)
CRSE CHCK	Cruise checklist will be displayed. (see Appendix 4)
LNDG CHCK	Before Landing checklist will be displayed. (see Appendix 4)
SHUT DOWN	Engine Shutdown checklist will be displayed. (see Appendix 4)
PERF CALC	Performance Calculation switch legends will be selected.
MTF (XXXX)	Maintenance Test Flight versions of the checklists designated by "XXXX" will be selected (provisional).
HIT CHCK	(Engine) Health Indicator Test calculation will be displayed. (see Section 3.2.2.2)
HVR PWR	Power Required to Hover (IGE and OGE) calculation will be displayed. (see Section 3.2.2.2)
MAX PWR	Maximum Available Power calculation will be displayed. (see Section 3.2.2.2)

TABLE 2. SWITCH LEGEND DESCRIPTIONS (CONT)

<u>Legend</u>	<u>Description</u>
WT & BAL	Weight and Balance Calculation will be displayed. (see Section 3.2.2.2)
SYST TEST	System Self Test will be initiated and displayed (provisional).
LMTS SUMM	Limits Summary will be displayed (maintenance data summarized - post-flight operation. See Section 3.2.2.3.)
(XXXX) ACK	Duplicates acknowledge switch function for faults in subsystem described by "XXXX". The "XXXX" portion of the legend also reflects the subsystem being displayed (with unacknowledged faults/emergency procedures checklists).
WARN ACK	Simultaneously acknowledges all currently active Warnings.

in that subsystem, provided the checklist has not been completed since fault detection. If there are none, the switch retains it's "PROC" legend and allows a review of all checklists for that subsystem, as previously described in Section 3.2.1.4.1. Upon completion of one checklist, the next highest priority one is automatically displayed. If no more exist, the display is cleared and the switch legend returns to "DATA" as shown in Figure 8a.

An emergency checklist for a Warning may not be removed from the display unless:

- a) The checklist is acknowledged as complete by using the ACK switch on "XXXX ACK" MLDS.
- b) A higher priority fault is detected.
- c) The fault related to the checklist is cleared.

A complete list of the emergency procedures checklists associated with the CH-47C is shown in Table 3. Before any such checklists are incorporated into EMMADS, they must be rewritten observing the following criteria:

- a) Checklists consisting of so called "immediate action" items will be displayed with the idea that they will be used by the pilot, after he has already completed the items, to verify completion. This is because the required speed of reaction does not allow time to "read and respond" to such items, as the aircraft operator's manuals currently indicate.
- b) Other checklists (or portions thereof) that have no immediate action items but which provide for natural follow on responses to them will be appended to those immediate action items (e.g., Engine Cleanup and Restart combined with Engine Failure checklist).

- c) Where applicable, these checklists will be displayed along with any raw data necessary for checklist accomplishment (e.g., Engine Restart shown with  $N_1$  and TGT). Formats are TBS pending final results of a human factors study.

A suitably rewritten version of the checklists in Table 3 is TBS.

TABLE 3. CH-47C EMERGENCY ACTION CHECKLISTS

Checklist	Related Fault(s)*
1. Failure of Two Engines - Low Altitude/Low Airspeed	61
2. Failure of Two Engines - Cruise	61
3. Failure of One Engine - Low Altitude/Low Airspeed	60
4. Failure of One Engine - Cruise	60
5. Engine Restart During Flight	60, 61
6. Engine Cleanup Procedure	60, 61
7. Normal Engine Beep Trim System Failure - High Side	62, 63
8. N2 Governor Failure	64, 65
9. Normal Engine Beep Trim System Failure - Low Side	66, 67
10. Engine Shutdown - Complete Electrical Failure	71
11. Engine Residual Fire During Starting and Shutdown	3, 4 (Rate Trigger)
12. Engine Fire - Ground	3, 4 (Rate Triger)
13. Single Fuel Pump Failure	25, 25, 27, 28
14. Fuel Cell Overpressure	17, 19, 20, 22, 68, 69
15. Fuel Pump System Failure	23, 24
16. Fuel Low and One or Both Aft Pumps Inoperative	17-22, 26, 28
17. Failure of Both Generators	71
18. Failure of Both Transformer Rectifiers	72



TABLE 3. CH-47C EMERGENCY ACTION CHECKLISTS (Cont'd)

Checklist	Related Fault(s)*
19. Failure of One Flight Control Hydraulic System	44,45
20. Failure of Both Flight Control Hydraulic Systems	70
21. Longitudinal Cyclic Trim Failure	53, 54
22. Single SAS Failure	55, 56
23. Dual SAS Failure	73

\* See Appendix 2 - Fault/Advisory List

### 3.2.2 System Secondary Functions

#### 3.2.2.1 Routine Checklists

The EMMADS secondary functions are related to the flight phases. It is convenient to define the time span from system power-up to power-down as a flight. Each flight, in turn, may be divided into a number of sorties where a sortie begins with a take-off (from the ground or from hover to forward flight) and ends with a landing (to a hover or to the ground). The EMMADS may then be envisioned as normally cycling through various states based on the stage of flight. The current operational state is described by the particular routine checklist which the system is currently running or last finished running. The checklists applicable to the CH-47C are shown in Table 4, including a set of operating conditions (called modification parameters) that modify the indicated checklists. The flight state numbers shown next to each checklist are used in Figure 10 to indicate how the EMMADS would progress from state to state in any flight. It should be noted that it would be quite natural to regroup these checklists into the categories illustrated in Figure 9.

In Figure 10, a method of communicating flight state changes to EMMADS is shown. Differentiation is made between two methods of progression from one state to the next. The sequential state change paths could be brought about through the use of the ACK switch. As EMMADS moves to a new flight state, the associated routine checklist could be displayed. After the last item in a given checklist is completed, (provided there are no faults requiring acknowledgement) actuation of the ACK switch would enable the next checklist in the sequence shown.

The specifically directed state change paths indicate that the crew must make some other input to the system to produce the

TABLE 4. CH-47C ROUTINE CHECKLISTS AND MODIFICATION PARAMETERS

Routine Checklists

<u>State</u>	<u>Checklist Title</u>
1	Before Starting Engines
2	Starting Engines
3	Engine Ground Operation
4	Before Taxi
5	Taxiing Check
6	Before Takeoff (to a hover)*
7	Hover Check
8	Before Takeoff (to forward flight)*
9	Cruise Check
10	Before Landing
11	After Landing
12	Engine Shutdown

\* (These checklists are identical in TM 55-1520-237-10-2. They are listed separately here in order to differentiate between two distinct flight modes.)

Modification Parameters

<u>Parameter</u>	<u>Affected Checklist(s)</u>
1. Through-Flight Operation with crew change	Before Starting Engines Starting Engines Engine Ground Operation
2. External Cargo Operation	Before Taxi Before Takeoff (8) Cruise Before Landing
3. Night Flight Operation	Starting Engines Engine Ground Operation Hover Check
4. Instrument Flight Operation	Starting Engines Engine Ground Operation Hover Check
5. Water Operation	Before Taxi Before Landing
6. Cold Weather Operation	Starting Engines
7. Hot Weather Operation	Engine Shutdown
8. Maintenance Test Flight Operation	All (except Before Takeoff and Before landing)

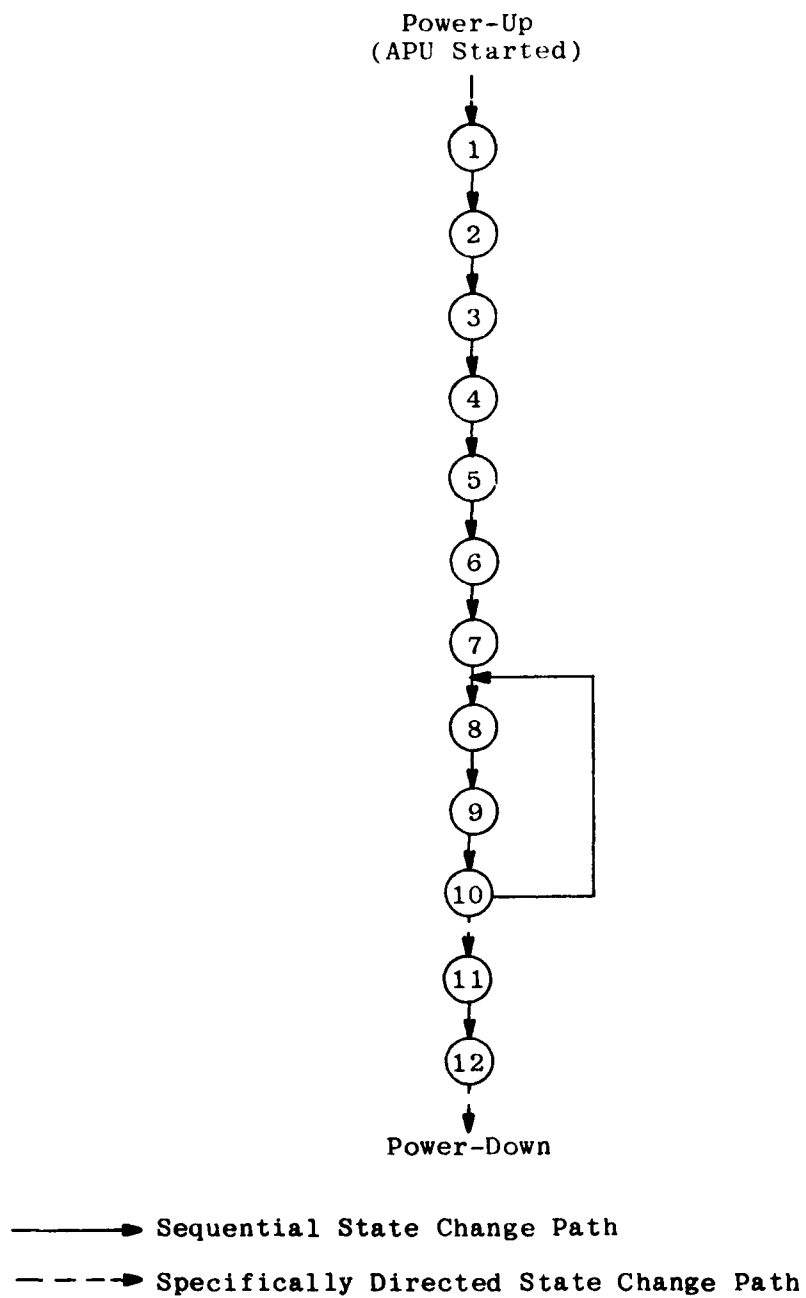


Figure 10. Normal Operational State Sequence

indicated state change. This would be accomplished by using one of the MLDS's described in Section 3.2.4.1.

The sequential state change operating scheme would make it easy for the pilot (without removing his hands from the flight controls) to display and accomplish those checklist items most often used in helicopter operations; Before Takeoff and Before Landing. This is a particularly useful feature for both operational and training type missions, where multiple takeoffs and landings are the rule.

Given this operating scheme it is advantageous at this point to consider a representative scenario for the EMMADS operation in order to highlight other features of the routine checklists. When the system powers up it will begin to sample parameter data and display any detected faults. If the EMMADS is powered up before engine start, many subsystems will have erroneous "fault" conditions associated with them. A method for disabling fault displays must be provided, so that as each subsystem powers up to normal operation, the associated fault conditions can be enabled for display. A convenient method for doing this is through the routine checklists such as STARTING ENGINES and ENGINE GROUND OPERATION. (Note: It is assumed that the APU must be running or that external power is connected before EMMADS is powered up. In the former case, provision would have to be made for bypassing the first part of the STARTING ENGINES checklist which deals with APU starting.) The sample scenario is shown below:

- a) The system powers up and enables all Advisory conditions for display. In addition, faults 11-22, 40-43, 47, 48, 57 and 58 are all enabled (see Appendix 3). The display at this point only contains data in the Dedicated Status Area unless any of the enabled faults are detected, in which case the display reflects the highest priority faults, as described in Section

3.2.1.3. During power up and initialization, the switch legends should be those shown in Figure 8a. If no faults are detected, the legends will remain in that state. If any faults are detected the relegendable switches will have their legends changed as described in Section 3.2.1.4.2.

- b) Once all faults are acknowledged the pilot may either select the Dedicated Status Area, specific subsystem data or initiate the STARTING ENGINES checklist by depressing the appropriate MLDS under the display.
- c) If the checklist option is elected, this essentially places the system in State 1 of the secondary functions mode, as shown in Figure 10. Although the final checklist formats are TBS (based on the final results of human factors testing), a sample format is illustrated in Figure 11. This shows the essential elements of an EMMADS managed checklist, which are:
  - (1) An indication by the system of what the current checklist item is,
  - (2) A description of the action(s) to be taken by the crew for each item plus the required response, and
  - (3) An acknowledgement by the system that an item is complete.

In this example the system identifies the current item by boxing the procedure description and the response. The pilot accomplishes the item and indicates completion by using the ACK switch. (Note that Figure 11 is the only exception to the rule that the Dedicated Status Area is always displayed. Once an engine is

Figure 11. Sample Display Format - Full Page Checklist

started the display area available for the checklist would no longer include the Dedicated Status Area.) of When the item is sensed as completed, the response message is changed to a " " or other suitable indication of completion and the next item is boxed. The response section contains a command word or a switch legend which changes during some sequenced operation, thereby modifying the action to be taken during the course of accomplishing that item. The pilot follows these instructed changes as they appear. The sequence of item completion may loop back to a previously accomplished item, changing the desired response for that item and boxing the procedure description and new response until completion is sensed by the system.

The checklists are indexed by having the current checklist item (boxed procedure description) move down from the top until it is in the middle of the screen. From this point on the checklist items are scrolled from bottom to top so that the current item always maintains the same relative screen position. When the last item in a checklist is completed, the next actuation of the ACK switch clears the display but the system remains in the state associated with that checklist (see Figure 10 and Table 4).

- d) If at any time an enabled fault is detected, that fault must be displayed in accordance with the procedures previously outlined. If a fault occurs while running a routine checklist, the checklist is replaced on the display until the fault is cleared and/or acknowledged. If there is an emergency procedures checklist that automatically follows on the acknowledgement of a



Warning then this checklist must be completed, as described in Section 3.2.1.5.

- e) If no checklist is being run and no faults are pending, actuation of the ACK switch or an appropriate MLDS causes a sequencing within the secondary functions mode to the next appropriate state (see Figure 10) and displays the routine checklist associated with that state.
- f) After the last approach is made and the aircraft is on the ground, the crew must manually select the AFTER LANDING CHECKLIST using the appropriate relegendable switch. Progression to the ENGINE SHUTDOWN CHECKLIST may then be accomplished using the ACK switch. As each system is shut down the faults normally associated with that shutdown are detected and displayed, thus allowing a post flight check of their operation. Acknowledgement of these faults clears them from the display and returns the display to the checklist at the appropriate point.

An example of the form that routine CH-47C checklists might take when rewritten for incorporation in an EMMADS is shown in Appendix 4. The section under the heading "EMMADS Actions" describes what the EMMADS does during each item and is not part of the displayed information. These checklists do not include any Maintenance Test Flight (MTF) checklists or the Emergency Start (EMER STRT) checklist listed in Table 2. These switch legends were provided to indicate such checklists as growth items for further development, since it is recognized that EMMADS must be compatible with maintenance test flight activities and also should enhance the pilot's ability to rapidly start the aircraft and evacuate it from a hazardous area (presumably under combat conditions). The checklists in Appendix 4 refer to the list of

faults in Appendix 3 by number, as regards the enabling of various fault conditions. For operations such as engine start where the pilot must normally cross correlate certain parameters (including time) with certain operations, EMMADS performs these functions for the pilot. For example, EMMADS correlates  $N_1$  acceleration with time during engine start and triggers a fault indication for  $N_1$  if ground idle speed is not attained 45 seconds into the start.

#### 3.2.2.2 Performance Calculations

(TBS)

#### 3.2.2.3 Maintenance Data Summary

(TBS)

Subsystem Parameter Data Lists  
for the  
CH-47C, UH-60A, OH-58C and YAH-64

APPENDIX I  
SUBSYSTEM PARAMETER DATA LIST  
FOR THE  
CH-47C

SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: CH-47C

Table: A1

SUBSYSTEM: Engine (T55-L-11D Only)

Sheet No.: 1

PARAMETER NAME - INDICATOR LABEL	INDICATOR		OPERATING MODE	CONDITION	PARAMETER		NOTE # (SH 4)
	TYPE	RANGE	MARKINGS		CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	
Eng Gas Producer Speed - NO. 1 (2) ENGINE PERCENT RPM	Circular Dials (2)	0-110	(Maximum)R (See Note)	60-63	Normal - continuous	-10-2, pp 2-25, 5-4 & 5-9, 8-7 & 16-1 -23-3, pp 8-1/2 -23-5, p F-64	1
					Normal - continuous		
					Maximum - continuous		
					Normal - Transient		
Engine Pwr Turbine Inlet Temperature - NO. 1 (2) ENGINE TEMP	Circular Dials (2)	0-1200	(399-770)G (788-927)Y (810)B (860)R (927)R (see note)	0-788 788-927 927 0-260 260-350 350 399-770 770-810 810-860 860 927	Eng Start	-10-2, pp 2-25, 5-4 & 10/11, 8-17 & 21 -23-3, pp 8-11/12 -23-5, p F-65	2
					Eng Shut-down		
					Other than Eng Start		
					Warning - 5 sec to 0 sec (see note)		
					Maximum - none allowed		
					Normal - continuous		
					Cautionary - Transient		
					Maximum - Transient		
					Normal - continuous		
					Cautionary - 30 minutes		
					Cautionary - 10 minutes		
					Maximum - 10 minutes		
					Maximum - none allowed		

Table: A1 (Engine - Cont'd)

Sheet No.: 2

PARAMETER NAME - INDICATOR LABEL	INDICATOR			OPERATING MODE	PARAMETER		REFERENCES (TM 55-1520-227)	NOTE # (SH 4)	
	TYPE	RANGE	MARKINGS		UNITS	CONDITION			CONDITION TYPE - DURATION
Eng Torque - ENGINE TORQUE PERCENT 1 (2)	Circular Dial w/Two Needles	0-150	(78)R (100)R	%	Single Engine	0-85 @ 245 NR	Normal - Continuous	-10-2, pp 2-25 & 5-3, 9/10 -23-3, pp 8-14/17 & F0-20 -23-5, p F-59	3
						0-89 @ 235 NR			
						0-91 @ 230 NR			
						85-97 @ 245 NR	Cautionary - 30 minutes		
						89-100 @ 235 NR			
						91-100 @ 230 NR			
						97-100 @ 245 NR	Cautionary - 10 minutes		
						100 @ 230-235 NR			
						100-138	Warning - Transient (10 seconds)		
						138	Maximum - 10 seconds		
Eng Bearing No. - 2 Oil Pressure - NO. 1 (2) ENGINE OIL PRESS	Circular Dials (2)	0-200	(20)R (35-90)G (110)R	psi	Dual Engine	0-78	Normal - continuous	-10-2, pp 2-25 & 5-4 -23-3, pp 8-5/6 -23-5, p F-62	4
						78-100	Cautionary - Transient (10 seconds)		
						100	Maximum - 10 seconds		
						20	Minimum - continuous		
						35	Minimum - continuous		
						35-50	Normal - continuous		
						50	Minimum - continuous		
						50-90	Normal - continuous		
						110	Maximum - unspecified		
						All			

Table: A1 (Engine - Cont'd)

Sheet No.: 3

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		NOTE # (SH 4)
	TYPE	RANGE	MARKINGS			CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	
Engine Oil Temperature - NO. 1 (2) ENGINE OIL	Circular Dials (2)	-70-150	(138)R	°C	All	Maximum - unspecified	-10-2, pp 2-25 & 5-4 -23-3, p 8-7 -23-5, p F-60	5
Engine Oil Level - OIL LOW NO. 1 (2) ENG	Caution Lgts (2)		Amber	qts	All	< 2.0 qts useable In the reservoir	-10-2, pp 2-25 & 70 -23-2, p 4-155 -23-5, p F-71	6
Eng Bearing & Accessory Gearbox Integrity - NO. 1 (2) ENG CHIP DET	Caution Lgts (2)		Amber	--	All	Sensor grounded by metal particles from eng bearings and/or gearing	-10-2, pp 2-26 & 71 -23-5, pp F-168/170	7
Eng Condition Lever Position/ Gas Producer Position Signal Error - NO. 1 (2) ENG M1 CONT	Caution Lgts (2)		Amber	--	All	Error signal detec- ted between engine condition lever position & gas producer actuator position, or eng condition lever is not in one of the detents	-10-2, pp 2-23 & 71 -23-2, pp 4-179/181 -23-5, p F-89	8

## NOTES:

1. Reference the Operator's Manual, p 5-9, paragraphs 5-23 and 5-24, the actual upper limit of the normal  $N_1$  speed range is obtained from the engine test log or the engine overhaul data plate. A cautionary limit is implied as being set from this maximum power speed up to 2% above this speed. However, the duration is only vaguely specified (i.e. "limit the time spent in that range"). The 103% figure was used since it is described as a maximum allowable  $N_1$  speed for Table 5-2. The  $N_1$  speed sensor is a tachometer generator (G704 - 3 phase ac type) which supplies a voltage to the indicator (M121 or M118) where the frequency is proportional to the compressor speed.
2. Figure 5-5 of the Operator's Manual indicates that for engine start, with a PITT at or above 788°C, the allowable time versus temperature equation is  $PITT = -27.8t + 927$  where  $t$  is in seconds and PITT is in °C. There is no specified relationship for PITT vs  $t$  below 788°C on engine start. Also, although not specifically stated, it is presumed that the above equation applies for acceleration and time limited operations between 927°C and 860°C. Sensors are 10 chromel-alumel thermocouple probes, connected to the indicators (M123), which are millivoltmeters. Also included in the circuit is a variable (spool) resistor (R101) which is set between 21.95 and 22.05 ohms.
3. The Operator's Manual specifies 78% and 100% as the transmission steady state torque limits for dual and single engine operations, respectively, and 100% and 130% as the corresponding transient limits. Sensors consist of a primary winding on the engine output shaft which rotates inside of a torque meter head containing a primary and two secondary windings. A 2KHz reference signal applied to the torque meter head assembly couples to a secondary winding while the rotating shaft induced signal is coupled to the other secondary winding. A junction box at each engine rectifies these voltages producing a difference voltage which is sensed and displayed as percent torque by the pilot's and copilot's indicators (M139 and M132).
4. Sensors are synchros (MT 710) which utilize 26 vac to produce a signal proportional to oil pressure, driving the No. 1 (2) engine indicators (M114 and M117). The operating mode for 20 psi minimum oil pressure is stated in the Operator's Manual as "ground idle". Normal  $N_1$  speed at ground idle is 60%-63% but this leaves undefined the 0-60% and 63%-70% ranges. Thus 45%-70%  $N_1$  was chosen to apply the 20 psi minimum oil pressure to as a range which would include the ground idle state with nearly all possible  $N_1$  speeds. Less than 45% would be a "don't care" condition since this would be a result of shutdown or a hung start.
5. Sensors are bimetallic thermistor type probes which change resistance linearly with temperature. The power to operate the No. 1 (2) indicators (M112 and M115) comes from the 28 VDC Primary Bus.
6. Sensors are level detecting micro switches in each oil tank which are grounded when the tripping threshold is reached. The signals are routed to the caution panel through connector pins F & H. If oil consumption exceeds 2 qts/hour, write up required (-10-2, p 2-24).
7. Sensors are three magnetic plugs positioned in the accessory gearbox sump, in the No. 2 bearing external oil return line and in the No. 4 & 5 bearings external oil return line. The plugs are likely grounded by metal chips, thus grounding pins A & B of the caution panel connector.
8. Sensors consist of a servo amplifier card to detect the position errors between the synchros in each engine control system. Additional sensors are the detent detecting microswitches for each engine condition lever. The error signal is sent to pins P173 E and X on the caution panel.



# SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: CH-47C

SUBSYSTEM: Fuel

Table: A2

Sheet No.: 1

PARAMETER NAME - INDICATOR LABEL	INDICATOR		MARKINGS	UNITS	OPERATING MODE	CONDITION	PARAMETER		NOTE # (SH 2)
	TYPE	RANGE					CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	
Fuel Quantity in the Aft, Main and Fwd Tanks on both the Left & Right Sides -	Circular Dial w/Pointer & Selector Switch	0-2300	None	lbs	All	0-(320-420)	Cautionary - unspecified	-10-2, pp 2-31/32, 53, 56, 71 & 75 -23-3, p F0-24 -23-5, p F-69	1
FUEL QUANTITY L(R) AFT, MAIN, FWD						(320-420)-6804	Normal - continuous		
FUEL QUANTITY TOTAL	No pointer indication but con- tinuous digital readout on dial. Inde- pendent of selector sw position.	0-9999	Amber			<(320-420)	Cautionary - unspecified		2
L(R) FUEL LOW	Caution Lgts (2)	--							
Engine Fuel Line Pressure -	Caution Lgts (2)	--	Amber	psi	Pressure altitude <6000'	<10	Cautionary - unspecified	-10-2, pp 2-31/32 & 70 -23-4, p F0-33 -23-5, p F-147/148	3
L(R) FUEL PRESS							Warning - none allowed		
Auxiliary Tank Fuel Boost Pump Pressure -	Press to Test Caution Lgts (2)	--	Amber	psi	All	<(9-11)	Cautionary - unspecified	-10-2, pp 2-32 -23-4, p F0-33 -23-5, p F-149	4
AUX PRESS LEFT (RIGHT) SIDE									

Table: A2 Fuel - Cont'd)

## NOTES:

1. Sensors are ten capacitance type probes, three in each main tank and one in each auxiliary tank. The three probes in each main tank are wired in parallel, with one of the resulting twin lead-outs from each tank wired to the selector switch, while the remaining lead-outs are tied together at the indicator. For the auxiliary tank probes, one line from each probe is connected to the selector switch and the other lines are tied together at the indicator. The cautionary range specification is based on the low fuel caution light threshold and not on a dial marking. Note that tank capacities are all different, even for like tanks (TMS5-1520-227-10-2, p 2-75).
2. Sensors are thermistor bead type units (A608 - Right and A609 - Left) at the lower end of the center fuel quantity probes (MT 604 and MT 609) in the main tanks. The signal is routed to the thermistor control unit (A142) which signals the caution panel when a main tank is down to about 20% of its capacity (see reference quoted in Note 1 above).
3. Sensors are pressure switches between the aft auxiliary tank and the engine fuel valves. The switch closes a path from the caution panel to ground when the low pressure threshold is reached. Operation above 6000' pressure altitude with the light on is likely to cause an engine flameout.
4. Sensors are four pressure switches, one for each auxiliary boost pump. The pressure switches on the same side of the aircraft provide a path to ground for the same light, but through the separate auxiliary boost pump switches (via a separate set of contacts in each switch) for that side. Thus, the pressure loss may be tracked to the specific line by alternately turning ON and OFF the Fwd and Aft Auxiliary Boost Pump switches for the affected side. Since power to the lights is through breakers which protect the pump relay power lines (see Table A5) a tripped circuit breaker would cause a fuel pressure loss with no light to show such loss.

SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: CH-47C

Table: A3

SUBSYSTEM: Powertrain

Sheet No.: 1

PARAMETER NAME - INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 3)	
	TYPE	RANGE	MARKINGS						UNITS
Rotor Speed - RPM ROTOR	Circular Dial	0-290	(214)R (214-232)Y (232-250)G (250-255)Y (255)R (261)R	RPM	Ground Ops, Min Beep, Eng Cond Lvs @ FLIGHT      Powered Flight	214	Minimum - continuous	-10-2, pp 2-45, 5-2, 3 & 9 -23-2, p 4-51 -23-3, pp 8-63 & 64 -23-5, p F-63	1
						214-232	Cautionary - unspecified (see note)		
						232	Minimum - continuous		
						235-245	Normal - continuous (245 rpm if gross weight >40,000 lbs)		
						250	Maximum - continuous		
						251-255	Maximum (power turbine limit) - 5 minutes		
						256-262.5	Maximum (power turbine limit) - 5 seconds		
Forward, Aft, Combining & Engine Gearboxes Oil Pressure - XMSN OIL PRESS	Circular Dial w/Selector Switch	0-100	(20)R (20-90)G	psi	Auto- tation      60% <N <sub>1</sub> ≤63%  N <sub>1</sub> >63%  All	232-261	Normal - continuous	-10-2, pp 2-41/43, 70 & 5-5 -23-3, pp 8-50/54 & F0-22 -23-5, p F-53 (Also 55-1500-210-MTF p 2-76)	2
						261-265	Cautionary - transient		
						265	Maximum - transient		
						10	Minimum - continuous		
						20	Minimum - continuous		
						20-90	Normal - continuous		
						≤20 +2	Cautionary - unspecified		
XMSN OIL PRESS	Caution Lgt	--	Amber					3	

Table: A3 (Powertrain Cont'd)

PARAMETER NAME - INDICATOR LABEL	TYPE	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		REFERENCES (TM 55-1520-227)	NOTE # (SH 3)
		RANGE	MARKINGS	UNITS			CONDITION TYPE -	DURATION		
Forward, Aft, Combining & Engine Gearboxes Oil Temp - XMSN OIL TEMP	Circular Dial w/Selector Switch	-70-150	(130)R (130-140)Y (140)R	°C	All	<130	Normal - continuous		-10-2, pp 2-42/43, 70/71, 5-5 & 9-9 -23-2, pp 6-173 & FO-12/13 -23-3, pp 8-57/62 -23-5, pp F-51/53 & 169	4
						130	Maximum (all but engine gearboxes) - continuous			
						130-140	Cautionary (engine gearboxes only) - 1 hour			
						140	Maximum (engine gearboxes only) - 1 hour			
XMSN OIL HOT	Caution Lgt	--	Amber			>130	Cautionary - unspecified (see above limits)			5
NO. 1 (2) ENG XMSN HOT	Caution Lgts (2)	--	Amber			>190	Cautionary - unspecified			6
Forward, Aft & Combining Gearboxes & Aft Vertical Shaft Thrust Bearing Integrity - XMSN CHIP DET	Caution Lgt	--	Amber	--	All	Sensor contacts grounded by metal particles from gearboxes or thrust bearing	Cautionary - unspecified		-10-2, pp 2-43 & 71 -23-2, pp 6-129/132, 135/137, 155 & FO-12/13 -23-5, pp F-168/170	7

Table: A3 (Powertrain - Cont'd)

## NOTES:

1. Sensor is identical to that used for the gas producer speed indicating system and is located on the Forward Transmission. The indicator is a dual pointer type, with an inner scale range of 0-130 RPM and an outer scale range of 130-290 RPM. Note that the normal rpm range during autorotation is based on the minimum green arc rpm and the specification by the Operator's Manual (p 5-2) of 261 rpm as the "maximum continuous rotor speed during autorotation". Note that although the range 214-232 is marked as a cautionary range, it is probably meant to be a transient range which is also normal for ground operations.
2. Sensor is a variable reluctance transducer which supplies a differential voltage, proportional to the sensed pressure, to selector switch circuitry associated with the indicator.
3. Sensor is a switch which is built into the oil pressure indicator (M103). The switch grounds the sensing lead from the caution panel when the threshold is reached for the gearbox being monitored by the oil pressure indicator selector switch. When the selector switch is in scan, the lowest pressure is displayed and the caution light will act as a warning device for whichever gearbox oil pressure goes below the minimum allowable.
4. Sensors are electrical resistance type temperature bulbs, calibrated to provide 1200 ohms at 0°C. They are incorporated into a wheatstone bridge where the resulting voltage imbalance drives a motor which moves the wiper arm of the bridge's variable resistor as well as the indicator pointer. The sensor used in the bridge depends on the position of the XMSN OIL TEMP selector switch. A faulty sensor is indicated by the pointer going above 150° when the selector switch is set to SCAN or below -70° when the switch is set to the faulty sensor's position.
5. Sensor is a switch in the temperature indicator described above. Again the light will only indicate an excessive temperature condition for the gearbox designated by the selector switch.
6. The system is installed only on aircraft #74-22276 and subsequent. Sensors are thermostats which are part of a combined chip detector/temperature sensor assembly. The sensing is most likely accomplished by grounding the lead from the caution panel for the affected caution capsule.
7. Sensors are bayonet-type electrical contact/magnetic plug combination detectors which provide a grounding path when ferrous type particles bridge the contacts. This ground is sensed by the caution panel circuitry, which lights the caution capsule.

SUBSYSTEM PARAMETER DATA LIST

Table: A4  
Sheet No.: 1

HELICOPTER: CH-47C

SUBSYSTEM: Hydraulic

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		REFERENCES (TM 55-1520-227)	NOTE # (SH 2)
	TYPE	RANGE	MARKINGS			CONDITION	DURATION		
Flight Control Hydraulic Pressure - NO. 1 (2) BOOST	Circular Dials (2)	0-4000	(2500)R (2500-3200)G (3200)R			2500	Minimum - continuous	-10-2, pp 2-40, 70 & 5-8 -23-3, pp 7-20, 24-25 -23-5, p F-50	1
						2500-3200	Normal - continuous		
						>3200	Maximum - continuous		
NO. 1 (2) HYD BOOST OFF	Caution Lgts (2)	--	Amber	All		<(2050-1950)	Cautionary - unspecified		2
Utility Hydraul- ic System Pressure - UTILITY	Circular Dial	0-4000	(2500)R (2500-3400)G (3400)R			2500	Minimum - continuous	-10-2, pp 2-40 & 5-8 -23-3, p F-15 -23-5, p F-121	3
						2500-3400	Normal - continuous		
						3400	Maximum - continuous		

Table: A4 (Hydraulic - Cont'd)

Sheet No.: 2

NOTES:

1. Sensors are 26 VAC, 400 Hz synchro units driving similar units for indicators. 200 psig fluctuations possible with rapid control movements. Normal tolerance  $\pm 50$  psig.
2. Sensors are pressure switches which ground the sensing lines from the caution panel. Power to the capsules is provided via the CAUTION LGTS circuit breaker. The switching threshold used is from the fourth page reference, versus the 2000-2100 psi threshold given in the first page reference.
3. Sensor is the same type as in Note 1 above. Normal tolerance  $\pm 50$  psig.

HELICOPTER: CH-47C

SUBSYSTEM PARAMETER DATA LIST

Table: A5

SUBSYSTEM: Electrical

Sheet No.: 1

PARAMETER NAME - INDICATOR LABEL	TYPE	INDICATOR		OPERATING MODE	CONDITION	PARAMETER		REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
		RANGE	MARKINGS			UNITS	CONDITION TYPE - DURATION		
Generator Output Suitability -					Volts out >132 vac (3 seconds), volts out <100 vac (3 phase aver., 5-7 seconds), freq. out <345 or feeder fault >33.3 amps. Generator discon- nected from the Primary or Sec- ondary bus respectively		Cautionary - unspecified	-10-2, pp 2-57 & 70 -23-3, pp 9-18/20, & F0-28 & 30 -23-5, p F-179	1
NO. 1 (2) GEN OFF	Caution Lgts (2)	--	Amber	All					
B Phase Generator Load -				Gener- ator on line	0-1.0		Normal - continuous		
NO. 1 (2) GEN	Circular Dials (2)	0-1.5	--	Gener- ator off line	1.0 - 1.5	Load Fract	Cautionary (overdraw) - unspecified	-10-2, p 2-13, 56 -23-3, p 8-67 & F0-28 -23-5, p F-179	2
AC External Pwr Connection & Suitability -					Positive or Negative Load		Cautionary - unspecified		
AC EXT PWR ON	Caution Lgt	--	Amber	All	External power is connected to the AC Primary Bus	--	Advisory - unspecified	-10-2, pp 2-57 & 70 -23-3, pp 9-18/20, & F0-28 & 30 -23-5, p F-179	3
DC Power Supply (Rectifier) Load -				Rectifier on line	0-1.0		Normal - Continuous		
NO. 1 (2) RECT	Circular Dials (2)	0-1.5	--	Rectifier off line	1.0 - 1.5	Load Fract	Cautionary (overdraw) - unspecified	-10-2, pp 2-13 & 57 -23-3, pp 8-65/66 -23-5, p F-135	4
DC Power Supply Output -					Output voltage of respective power supply less than that of bus it supplies. Power supply discon- nected from bus		Cautionary - unspecified		
NO. 1 (2) RECT OFF	Caution Lgts (2)	--	Amber	All		--		-10-2, pp 2-57 & 70 -23-3, pp 9-1/3, 11 & F0-26 -23-5, p F-135	5



Table: A5 Electrical (Cont'd)

Sheet No.: 2

PARAMETER NAME - INDICATOR LABEL	INDICATOR				PARAMETER			REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	CONDITION TYPE - DURATION		
DC External Pwr Connection and Suitability -	Caution Lgt	--	Amber	--	All	External power is connected to the DC Primary Bus	Advisory - unspecified	-10-2, pp 2-57 & 71 -23-3, pp 9-2/3, 12 & F0-26 -23-5, p F-135	6
DC EXT PWR ON									
Generator No. 2, Bus Tie & Aux. Bus Relays (K103, K105 & K107) Power Overdraw -	Tripped Crcr Brkr (CB 110)	--	5	Amps	Both gen- erators on line	>5 amps to all re- lays from the 28 VDC Primary Bus		-10-2, pp 2-54 & 59 -23-3, pp F0-28 & 30 -23-5, p F-179	
AC BUS CONT					Eng. Start	>5 amps to relays K105 & K103 only. Same power source.			
					Gen. No. 2 off line	>5 amps to relays K107 & K105 only. Same power source			
115 VAC Primary Bus Power Overdraw -	Tripped Crcr Brkrs (CB 1031, CB 1033 & CB 1035)								7
A PH FDR									
115V AC PRI BUS FEEDERS	Tripped Crcr Brkrs (CB 199, CB 1001 & CB 1003)					>10 amps through respective breaker set from the 208 VAC Primary Bus, A phase			
115 VAC Secondary Bus Pwr Overdraw -	Tripped Crcr Brkrs (CB 1015, CB 1017 & CB 1019)								
B PH FDR									
115V AC SEC BUS FEEDERS	Tripped Crcr Brkrs (CB 1005, CB 1007 & CB 1009)		10	Amps	All	>10 amps through respective breaker set from the 208 VAC Secondary Bus, B phase		-10-2, pp 2-52/53 & 55 -23-5, p F-185	8
26 VAC Instrument Bus Pwr Overdraw -	Tripped Crcr Brkrs (CB 1041, CB 1043 & CB 1045)								
26 VAC FDR									
26 VAC INSTR BUS FEEDERS	Tripped Crcr Brkrs (CB 1012, CB 1014 & CB 1016)					>10 amps through respective breaker set from the out- put winding of the 115/26V transformer			

Table: A5 Electrical (Cont'd)

Sheet No.: 3

INDICATOR			PARAMETER			REFERENCES (TM 55-1520-227)	NOTE # (SP 21)
PARAMETER NAME- INDICATOR LABEL	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	
115/26V Trans- former Primary Pwr Overdraw - 115-26V XFMR	Tripped Crcr Brkr (CB 1039)		5		All	>5 amps to the pri- mary winding from the 208 VAC Primary Bus (phase unknown)	-10-2, pp 2-52/53 & 55 -23-5, p F-185
DC Power Supply Pwr Overdraw - XFMR RECT NO. 1 (2)	Tripped Crcr Brkr (CB 1011 & CB 1013)		35			>35 amps to the re- spective pwr supply from the 208 VAC Primary and Sec- ondary Busses respectively	
Bus Tie & Radio Bus Tie Relays (K112 & K116) Pwr Overdraw -	Tipped Crcr Brkr (CB 1024 & CB 1090)		5		#1 Pwr Supply off, #2 on	>5 amps to relays through CB 1090, from the 28 VDC Secondary Bus	
DC BUS CONT NO. 1 (2)				Amps	#2 Pwr Supply off, #1 is on	>5 amps to relays through CB 1024 (unless an engine is being started) from the 28 VDC Primary Bus	-10-2, pp 2-54, 56 & 59 -23-3, pp 9-10 & F0-26 -23-5, pp F-135 & 141
Reverse Cur- rent Relays (K126 & K128) Volt Relay Coil, Bias Coil & Main Cont Coil Power Overdraw - REV CUR CO NO. 1 (2)	Tripped Crcr Brkr (CB 1018 & CB 1020)		15		All	>15 amps to relays of respective RCR (K126 or K128) from the output of the respective power supply	
External Power (K114) & Ex- ternal Power Control (K122) Relays Power Overdraw - DC EXT PWR CONT	Tripped Crcr Brkr (CB 1022)					>15 amps to the relays from the DC External Power source	

Table: A5 Electrical (Cont'd)

Sheet No.: 4

PARAMETER NAME- INDICATOR LABEL		INDICATOR			OPERATING MODE	CONDITION	PARAMETER CONDITION TYPE - DURATION		REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
		TYPE	RANGE	MARKINGS						
Overhead Panel Battery Bus Pwr Overdraw - BTRY BUS FEEDER		Tripped Crcr Brkr (CB 1026)		15	All	>15 amps to the bus from the DC Circuit Breaker Box Battery Bus				
Overhead Panel 28 VDC Primary Bus Power Overdraw - 28 VDC PRIMARY BUS FEEDERS		Tripped Crcr Brkr (CB 1046, CB 1048 & CB 1050)		35		>35 amps through the respective breaker set, from the DC circuit breaker box 28 VDC Primary Bus				
28V DC PRI BUS FEEDERS		Tripped Crcr Brkr (CB 1034, CB 1036 & CB 1038)								
Overhead panel 28 VDC Sec- ondary Bus Power Overdraw - 28 VDC SECONDARY BUS FEEDERS		Tripped Crcr Brkr (CB 1028, CB 1030 & CB 1032)		50		>50 amps through the respective breaker set from the DC circuit breaker box 28 VDC Secondary Bus				
28V DC SEC BUS FEEDERS		Tripped Crcr Brkr (CB 1040, CB 1042 & CB 1044)								
Engine Con- dition Relays (K503 & K505) and Beep Trim Actuators Pwr Overdraw - ENG TRIM DC NO. 1 (2)		Tripped Crcr Brkr (CB 130 & CB 167)		5		>5 amps to appli- cable relay and respective engine beep trim actuator from the 28 VDC Primary Bus			-10-2, pp 2-23, 56 & 59 -23-2, pp 4-190/192 & FO-11	

Table: A5 Electrical (Cont'd)

Sheet No.: 5

PARAMETER NAME- INDICATOR LABEL	INDICATOR		PARAMETER		REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
	TYPE	RANGE	MARKINGS	UNITS	CONDITION	
Engine Power Turbine Control Box & Actuator Pwr Overdraw - ENG TRIM AC NO. 1 (2)	Tripped Crc't Brkrs (CB 132 & CB 171)				>5 amps to respec- tive engine sys- tems from the I15 VAC Primary Bus	-10-2, pp 2-23, 56 & 59 -23-2, pp 4-190/192 & F0-11
Engine Power Turbine Actuator Pwr Overdraw - EMERG ENG TRIM	Tripped Crc't Brkr (CB 169)		5	Amps	>5 amps to respec- tive actuator from the 28 VDC EMER TRIM switch actuated	
Engine Start Valve (L707), Utility System Start Valve (L721), Relays K104 & K108 Pwr Overdraw - NO. 1 (2) ENG START	Tripped Crc't Brkrs (CB 122 & CB 163)				>5 amps to systems from the 28 VDC Primary Bus	
No. 1 (2) Eng Start Fuel Solenoid & Ignition Exciter Pwr Overdraw - IGNITION ENG NO. 1 (2)	Tripped Crc't Brkrs (CB 124 & CB165)		10		>10 amps to solen- oids (with respec- tive switches ON) from the 28 VDC Primary Bus	-10-2, pp 2-22, 24, 56 & 59 -23-2, pp 4-158/159 & F0-9/10 -23-3, pp 7-142/143 & F0-15 -23-5, pp F-83 & 121

Table: A5 Electrical (Cont'd)

Sheet No.: 6

PARAMETER NAME- INDICATOR LABEL	INDICATOR			PARAMETER		REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	
Ground Idle Pwr Interlock Relay & Gas Producer Control Relay Normal Power Overdraw - ENG COND CONT NO. 1 (2)	Tripped Crc't Brkrs (CB 1087 & CB 1094)				Respec- tive eng condi- tion lever in GROUND position (inter- lock sw closes)	>5 amps to system from the 28 VDC Primary Bus	-10-2, pp 2-22/23, 56 & 59 -23-2, pp 4-179/181 & FO-9/10 -23-5, p F-91
Thrust Control Magnetic Brake Pwr Overdraw - THRUST BRAKE	Tripped Crc't Brkr (CB 107)					>5 amps to brake from the 28 VDC Primary Bus	-10-2, pp 2-33, 56, 58 & 59 -23-3, p 9-95 -23-5, p F-48
Fairing Hot Air Valve Power Overdraw - ENG NO. 1 (2) ANTI-ICE	Tripped Crc't Brkrs (CB 145 & CB 147)					>5 amps to the respective valves (type 114PS208-3) from the 28 VDC Primary Bus	-10-2, pp 2-20, 56 & 59 -23-2, pp 4-134 & 135
Engine Power Supply Power Overdraw - NO. 1 (2) ENG TORQUE DC	Tripped Crc't Brkrs (CB 1077 & CB 1079)				All	>5 amps to the re- spective power sup- ply which provides the 2 KHz refer- ence signal to the torque meter head assembly. Power is from the 28 VDC Primary Bus	-10-2, pp 2-52, 53 & 59 -23-3, p FO-20 -23-5, p F-59
Engine Torque- meter Indicator Pwr Overdraw - NO. 1 (2) ENG TORQUE AC	Tripped Crc't Brkrs (CB 1073 & CB 1075)					>5 amps to the co- pilot's & pilot's indicators, re- spectively, from the 115 VAC Primary Bus	

Table: A5 Electrical (Cont'd)

Sheet No.: 7

INDICATOR				PARAMETER			NOTE # (SH 21)		
PARAMETER NAME- INDICATOR LABEL	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION		CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)
Engine Oil Pressure Systems Pwr Overdraw - PRESS IND ENG OIL	Tripped Crcr Brkr (CB 116)					>5 amps to the transmitters & indicators from the 26 VAC INSTR BUS		-10-2, pp 2-25, 53 & 56 -23-3, p 8-6 -23-5, p F-62	12
Engine Oil Temperature Indicators Pwr Overdraw - ENG OIL TEMP	Tripped Crcr Brkr (CB 121)					>5 amps to the indicators from the 28 VDC Primary Bus		-10-2, pp 2-56 & 59 -23-3, p 8-10 -23-5, p F-60	
Main Fuel Boost Pump Relays (K411 & K413) Pwr Overdraw - FUEL PUMP CONTROL L FWD (AFT)	Tripped Crcr Brkr (CB 1052 & CB 1047)					>5 amps to relays K411 & K413, respectively, in the Left Relay Box (114E2015-10) from the 28 VDC Primary Bus			
FUEL PUMP CONTROL R FWD (AFT)	Tripped Crcr Brkr (CB 1049 & CB 1051)		5	Amps	All	>5 amps to same relay numbers as above but in the Right Relay Box, same pwr source		-10-2, pp 2-27/29, 53, 55/56 & 59 -23-4, p 10-116 -23-5, p F-147	
Main Fuel Boost Pumps Power Overdraw - FWD LH (RH) FUEL PUMP	Tripped Crcr Brkr (CB 1027 & CB 1029)					>5 amps to the respective pump from the AC Primary Bus			
AFT LH (RH) FUEL PUMP	Tripped Crcr Brkr (CB 1025 & CB 1023)					>5 amps to the respective pump from the AC Secondary Bus			

Table: A5 Electrical (Cont'd)

PARAMETER NAME - INDICATOR LABEL	TYPE	INDICATOR		MARKINGS	UNITS	OPERATING MODE	PARAMETER		NOTE # (SH 21)
		RANGE	CONDITION				CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	
Auxiliary Fuel Boost Pump Relays (K409 & K415) Power Overdraw -	Tripped Crcr Brkrs (CB 1067 & CB 1069)		>5 amps to relays K409 & K415, re- spectively, in the Left Relay Box (114E2015-10) from the 28 VDC Secon- dary Bus (also to L Low Aux Press light, DS1070, if either right side aux fuel boost pump SW is ON)						
AUX TANK FUEL PUMP CONT L FMD (AFT)			>5 amps to same relay numbers as above but in the Right Relay Box, same pwr source. (Also to R Low Aux Press light, DS 1041, if either left side aux fuel boost pump switch is ON.)					-10-2, pp 2-27/29, 53, 55/56 & 59 -23-4, p 10-115 -23-5, p F-149	
AUX TANK FUEL PUMP CONT R FMD (AFT)	Tripped Crcr Brkrs (CB 1063 & CB 1065)				5	All			
Auxiliary Fuel Boost Pumps Pwr Overdraw -	Tripped Crcr Brkrs (CB 1059 & CB 1055)								
FMD LH (RH) AUX FUEL PUMP									
AFT LH (RH) AUX FUEL PUMP	Tripped Crcr Brkrs (CB 1061 & CB 1067)								
Crossfeed Fuel Valves and Crossfeed Fuel Lights Power Overdraw -	Tripped Crcr Brkr CB 1010								
FUEL CONT XFEED									13

Table: A5 Electrical (Cont'd)

Sheet No.: 9

INDICATOR			PARAMETER		OPERATING MODE	UNITS	MARKINGS	RANGE	TYPE	CONDITION	CONDITION: TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
PARAMETER NAME - INDICATOR LABEL													
Emergency Eng- Fuel Shutoff Valve Power Overdraw -									Tripped Crcr Brkr (CB 197 & CB 195)	>5 amps to respec- tive valves and their associated indicator lights, from the 28 VDC Primary Bus		-10-2, pp 2-30, 56 & 59 -23-4, p 10-104 -23-5, pp F151-152	13
FUEL SHUTOFF ENG NO. 1 (2)													
Fuel Quantity Indicator Power Overdraw -									Tripped Crcr Brkr CB 118	>5 amps to the gauge from the 115 VAC Primary Bus		-10-2, pp 2-31, 53, 56 & 59 -23-3, pp 8-87 & F0-24 -23-5, pp F-69	
FUEL QTY IND													
Low Fuel (Thermistor Control) Unit Pwr Overdraw -									Tripped Crcr Brkr CB 120	>5 amps to the con- trol unit from the 28 VDC Primary Bus			
FUEL CONT QTY													
Transmission Oil Pressure Indicating Sys Pwr Overdraw -									Tripped Crcr Brkr (CB 119)	>5 amps to system from 115 VAC Primary Bus		-10-2, pp 2-41, 53 & 56 -23-3, p F0-22 -23-5, p F-53	
XMSN OIL IND PRESS													
Transmission Oil Temperature Indicating Sys Pwr Overdraw -									Tripped Crcr Brkr (CB 106)	>5 amps to system from 115 VAC Primary Bus		-10-2, pp 2-42/43, 53 & 56 -23-3, pp 8-57 & 58 -23-5, p F-51	
XMSN OIL IND TEMP													
Hydraulic Pressure Transmitter & Indicator Synchros Pwr Overdraw -									Tripped Crcr Brkr (CB 108)	>5 amps to units from the 26 VAC Instrument Bus		-10-2, pp 2-53 & 56 -23-3, pp 8-47 & 9-93/95 -23-5, pp F-40 & 49	
PRESS IND HYD													



Table: A5 Electrical (Cont'd)

Sheet No.: 10

PARAMETER NAME - INDICATOR LABEL	INDICATOR			OPERATING MODE	PARAMETER		REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
	TYPE	RANGE	MARKINGS		CONDITION	CONDITION TYPE - DURATION		
Accessory and Utility Solen- oid (L179), Thermal Switch (S711) & Air Cooler Solen- oid Valve (L717) Power Overdraw -	Tripped Crcr Brkr (CB 175)				>5 amps to units from the Battery Bus		-10-2, pp 2-40, 56 & 58 -23-3, p F0-15 -23-5, pp F-83, 121 & 125	
UTILITY HYD SYS								
Flight Control Hydraulic Boost Solenoids Pwr Overdraw -	Tripped Crcr Brkr (CB 109)				>5 amps to solen- oids from the 28 VDC Secondary Bus		-10-2, pp 2-40, 56 & 59 -23-3, p F0-14 -23-5, p F-49	
HYD BOOST CONT								
Pitch Stability Augmentation System Power Overdraw -	Tripped Crcr Brkr (CB 103)		5	Amps	>5 amps to the centering spring & speed trim ampli- fier from the 28 VDC Secondary Bus		-10-2, pp 2-36/37, 56 & 59 -23-5, p F-41	
SPEED TRIM DC								
Differential Collective Pitch Trim Sys Pwr Overdraw -	Tripped Crcr Brkr (CB 101)				>5 amps to the speed trim ampli- fier from the 115 VAC Secondary Bus			
SPEED TRIM AC								
#1 and #2 SAS Amplifiers DC Voltage Supply and Hydraulic Solenoid Valves Pwr Overdraw -	Tripped Crcr Brkr (CB 117 & CB 115)				>5 amps to systems from the 28 VDC Primary Bus		-10-2, pp 2-35, 52/56 & 59 -23-3, p 9-95 -23-5, p F-45	14
NO. 1 (2) SAS DC								

Table: A5 Electrical (Cont'd)

Sheet No.: 11

PARAMETER NAME - INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
	TYPE	RANGE	MARKINGS					
#1 and #2 SAS Amplifiers AC Voltage and Rate Gyros Pwr Overdraw - NO. 1 (2) SAS AC	Tripped Crcr Brkr (CB 113 & CB 111)		5		>5 amps to systems from the 115 VAC Primary Bus		-10-2, pp 2-35, 52/56 & 59 -23-3, p 9-95 -23-5, p F-45	
Centering Device Release Mechanisms Pwr Overdraw - CONT CTR	Tripped Crcr Brkr (CB 105)		7	All	>5 amps to yaw magnetic brake & pitch and roll trim actuators from the 28 VDC Battery Bus		-10-2, pp 2-33, 56, 58 & 59 -23-3, p 9-95 -23-5, p F-48	15
Manually Com- manded Cyclic Trim Actuators Pwr Overdraw - CYCLIC TRIM ACT AFT (FWD)	Tripped Crcr Brkr (CB 102 & CB104)				>7.5 amps to the respective actu- ators through the corresponding manual operation switches, from the 28 VDC Primary Bus		-10-2, pp 2-36/37, 56 & 59 -23-5, p F-41	
Caution Panel and/or Master Caution Lights, & Troop Jump Signal Light Dimming Relay (K110) Power Overdraw - CAUTION LGTS	Tripped Crcr Brkr (CB 112)		5	Bright/ Dim sw at BRIGHT	>5 amps to system including negative fault sensed/ triggered caution capsule lamps, but excluding K110, from the 28 VDC Primary Bus		-10-2, pp 2-56 & 59 -23-3, pp 9-95, 98/99 & F0-28 -23-5, pp F-77, 161, 171 & 181	
Pitot Tube Heater Pwr Overdraw - PITOT HEAT	Tripped Crcr Brkr (CB 137)		5	Bright/ Dim sw at DIM  All	Same as above but including K110  >5 amps to heaters from the 115 VAC Secondary Bus		-10-2, pp 2-45, 53 & 56 -23-3, pp 8-30/31 & 36 -23-5, p F-73	

Table: A5 Electrical (Cont'd)

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		NOTE # (SH 21)
	TYPE	RANGE	MARKINGS			CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	
Side Slip Port Heaters Power Overdraw - STATIC PORT HTR	Tripped Crcr Brkr (CB 139)		7		>7.5 amps to heaters from the 115 VAC Secondary Bus		-10-2, pp 2-45, 53 & 56 -23-3, pp 8-30/31 & 36 -23-5, p F-73	
Pilot, Center & Copilot Wind- Temperature Controllers (A108, A110 & A112, resp.) and Anti-Ice Prelays (K119, K102 & K121 respectively) Pwr Overdraw - WSHLD ANTI-ICE CONT PILOT (CTR, COPILOT)	Tripped Crcr Brkrs (CB 149, CB 153 & CB 151)		5	Amps	>5 amps to the re- spective tempera- ture controller & relay from the 28 VDC Secondary Bus, through the re- spective circuit breaker		-10-2, pp 2-45, 53, 55/56 & 59 -23-4, pp 12-1/4 -23-5, p F-79	
Pilot, Center & Copilot Wind- Shield Heating Element Power Overdraw - WSHLD AI	Tripped Crcr Brkrs (CB 155, CB 157 & CB 159)		25		>25 amps (CB 155 & CB 159) to the pilot and copilot windshield heating elements (respec- tively) from the 115 VAC Secondary Bus (phases A & C)			
			10		>10 amps (CB 157) to the center wind- shield heating ele- ment from the 115 VAC Secondary Bus (phase B)			

Table: A5 Electrical (Cont'd)

Sheet No.: 13

PARAMETER NAME - INDICATOR LABEL	INDICATOR		UNITS	OPERATING MODE	PARAMETER		REFERENCES (TM 55-1520-227)	NOTE # (SEE ET)
	TYPE	RANGE			CONDITION	CONDITION TYPE - DURATION		
Windshield Wiper Motor Pwr Overdraw - WSHLD WIPER	Tripped Crcr Brkr (CB 170)		10		>10 amps to motor from the 28 VDC Secondary Bus		-10-2, pp 2-46, 56 & 59 -23-4, p 12-27 -23-5, p F-117	
Cockpit Utility Receptacles Pwr Overdraw - UTILITY REC PILOT (COPILOT)	Tripped Crcr Brkrs (CB 168 & CB 166)				>15 amps to the re- spective unit from the 28 VDC Secondary Bus			
Cabin Utility Receptacles Pwr Overdraw - UTILITY RECEPTACLE LH FWD (AFT)	Tripped Crcr Brkrs (CB 178 & CB 176)		15	All	>15 amps to the respective unit from the 28 VDC Secondary Bus		-10-2, pp 2-46, 53/55 & 59 -23-3, pp 9-7/11 & 45/46 -23-5, p F-114 & 129	
UTILITY RECEPTACLE RH FWD	Tripped Crcr Brkr (CB 172)							
UT RECP RH AFT	Tripped Crcr Brkr (CB 174)							
Missile Warmup Receptacles 1 & 2 Power Overdraw - MISSILE WARM UP #1 (2)	Tripped Crcr Brkrs (CB 179 & CB 177)				>15 amps to the respective unit from the 208 VAC Auxiliary Bus & the 208 VAC Secondary Bus, respectively		-10-2, pp 2-47/48, 52, 53 & 55 -23-3, pp 9-48/49 -23-5, p F-127	
Strobex Blade Tracking Receptacle Pwr Overdraw - BLADE TCK	Tripped Crcr Brkr (CB 1066)		5		>5 amps to outlet from the 28 VDC Secondary Bus		-10-2, p 2-48, 54 & 59 -23-5, pp F-130/131	

Table: A5 Electrical (Cont'd)

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
	TYPE	RANGE	MARKINGS					
Heater Blower Pwr Overdraw - BLOWER	Tripped Crc't Brkr (CB 141)		15	All	>15 amps to the blower on any or all phases, from the 208 VAC Auxiliary Bus			
Heater System Relays (K137, K205, K207, K209, & K211), Temperature Controller, Thermostat, Fuel Control, Ignition and Master Fuel Valve Solenoid Pwr Overdraw - HEATER CONT	Tripped Crc't Brkr (CB 143)		7	Heating Sw at VENT BLOWER ONLY	>7.5 amps to relay K137 from the 28 VDC Primary Bus	-10-2, pp 2-49, 52, 55/56 & 59 -23-4, p 13-7 -23-5, p F-77		
				Heating Sw at HEATER ON, heater running	>7.5 amps to all components. Same power source.			
				Heating Sw at HEATER ON, heater started but cycled off	>7.5 amps to all components except the Fuel Control solenoid valve. Same power source.			
				Heating Sw at HEATER ON, HEATER HOT caution light on	>7.5 amps to all relays except K137 and K205. Same power source.			

Table: A5 Electrical (Cont'd)

PARAMETER NAME - INDICATOR LABEL	TYPE	INDICATOR			OPERATING MODE	CONDITION	PARAMETER CONDITION TYPE - DURATION	DIFFERENCES (TM 55-1520-227)	NOTE # (SH 21)
		RANGE	MARKINGS	UNITS					
Right Aft Lndg Gear Swivel Lock, Power Steering Con- trol Valve, Actuator and Control Box Pwr Overdraw - AFT WHEEL	Tripped Crcr Brkr (CB 185)		7.5		Power Steering OFF	>7.5 amps to swivel lock mani- fold from the 28 VDC Primary Bus when AFT WHEELS switch position is changed		-10-2, pp 2-7, 54 & 59 -23-3, pp 7-253 -23-5, p F-128	
Cargo Hook Control Relay (L407) and Release Valve Solenoid (L403) Pwr Overdraw - CARGO HOOK CONT	Tripped Crcr Brkr (CB 180)			Amps	All	>5 amps to compo- nents from the 28 VDC Secondary Bus		-10-2, pp 2-71 & 4-25 -23-4, p 16-143 -23-5, p F-119	
Cargo Hook Emergency Release Valve Solenoid (L405) Power Overdraw - CARGO HOOK EMER	Tripped Crcr Brkr (CB 182)		5			>5 amps to L405 from the 28 VDC Emergency Bus			
Winch Hydraulic Control Valve (L201), Brake Release Solen- oid (L203) & Hoist Control Pwr Overdraw - HOIST CONT	Tripped Crcr Brkr (CB 183)				Hoist Control Sw at OFF	>5 amps to L203 from the 28 VDC Secondary Bus			
					Hoist Control Sw at IN or OUT	>5 amps to L201. Same power source.		-10-2, pp 2-56, 59 & 4-12 -23-4, p 14-4 -23-5, p F-115	
Hoist Cable Cutter (L401) Pwr Overdraw - HOIST CUTTER	Tripped Crcr Brkr (CB 181)		10			>10 amps to cutter from the 28 VDC Primary Bus			

Table: A5 Electrical (Cont'd)

Sheet No.: 16

PARAMETER NAME - INDICATOR LABEL		INDICATOR			PARAMETER			REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	CONDITION TYPE - DURATION			
Position Lgts Pwr Overdraw - POS LTS	Tripped Crcd Brkr (CB 140)				>5amps to system from the 28 VDC Secondary Bus		-10-2, pp 2-56, 59 & 61/62 -23-3, pp 9-67/68 -23-5, p F-103		
Anti-Collision Lights Power Overdraw - ANTI COLL LTS TOP (BOTTOM)	Tripped Crcd Brkrs (CB 142 & CB 144)			All	>5 amps to each light through the respective brkr, from the 28 VDC Secondary Bus				
Formation Lgts and Control Pwr Overdraw - FORM LTS	Tripped Crcd Brkr (CB 1053)				>5 amps to system from the 115 VAC Primary Bus		-10-2, pp 2-53, 55 & 62 -23-3, pp 9-83/84 -23-5, p F-102		
Pilot & Copilot Searchlght Ctrl Motors & Relays Pwr Overdraw - SLT CONT PILOT (CO PILOT)	Tripped Crcd Brkrs (CB 152 & CB 154)		5	Amps	Search- light control sw at L or R Bus	>5 amps to rotation motor and applica- ble relay from the 28 VDC Secondary Bus	-10-2, pp 2-55/56, 59 & 63 -23-3, p 9-73 -23-5, p F-105		
					Search- light control sw at EXTEND	>5 amps to ext/ret motor and extend relay. Same power source.			
					Search- light control sw or overhead panel control sw at RETR	>5 amps to ext/ret motor & retract relay (plus rota- tion motor & right relay if light is being fully retracted). Same power source.			

Table: A5 Electrical (Cont'd)

Sheet No.: 17

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		NOTE # (SH 21)
	TYPE	RANGE	MARKINGS			CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	
Pilot & Copilot Searchlight Lamp Power Overdraw - SL FIL PLT (COPLT)	Tripped Crcr Brkr (CB 148 & CB 150)		25		>25 amps to re- spective filament from the 28 VDC Secondary Bus		-10-2, pp 2-55/56, 59 & 63 -23-3, p 9-73 -23-5, p F-105	
Overhead Switch and Crcr Brkr Panels and Dimming Rheostats Pwr Overdraw - OVRHD PNL LTS	Tripped Crcr Brkr (CB 138)				>5 amps to system from the 28 VDC Primary Bus		-10-2, pp 2-56, 59 & 63 -23-3, p 9-63 -23-5, p F-101	
Pilot & Copilot Flight Instrument Lights, Center Section and Dimmer Rheostats Pwr Overdraw - INSTRUMENT LTS PILOT (COPILOT & CTR)	Tripped Crcr Brkr (CB 160, CB 134 & CB 136)		5	All	>5 amps to light- ing system from the 28 VDC Pri- mary Bus, through the respective breaker (except for the turn & slip and cruise guide indicators during an AC or DC Primary Bus fail- ure. In that case the instruments receive power from the Secondary Cockpit Lights circuit breaker (CB 162).		-10-2, pp 2-56, 59 & 63/64 -23-3, p 9-63 -23-5, p F-95/97	
Console Lights and Dimmer Rheostat Pwr Overdraw - CONSOLE LTS	Tripped Crcr Brkr (CB 173)				>5 amps to system from the 28 VDC Primary Bus		-10-2, pp 2-56, 59 & 64 -23-3, p 9-62 -23-5, p F-98	



Table: A5 Electrical (Cont'd)

Sheet No.: 18

INDICATOR				PARAMETER		REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION		
Cabin Dome and Utility Lights and Dimmer Rheostats Power Overdraw - COCKPIT LTS	Tripped Crcr Brkr (CB 158)			All	>5 amps to oper- ating systems from the 28 VDC Battery Bus	-10-2, pp 2-56, 59 & 64 -23-3, p 9-56 -23-5, p F-106	
Secondary Cockpit Lights and Dimmer Rheostats, Turn and Slip and Cruise Guide Indicator Lgts Pwr Overdraw - SECONDARY CRPT LTS	Tripped Crcr Brkr (CB 162)	5		AC & DC Primary Busses on line	>5 amps to all lgt systems (except the turn & slip and cruise guide indicator lights) from the 29 VDC Battery Bus	-10-2, pp 2-56, 59 & 64 -23-3, pp 9-57/59 -23-5, p F-107	
Cabin and Ramp Lights & Relays (K201 & K203), Jump Light Dim- ming Relay (K300) and Emergency Exit Lights Charge Pwr Overdraw - CABIN LTS	Tripped Crcr Brkr (CB 156)	10	Amps	AC or DC Primary Bus off line	>5 amps to all light systems. Same power source.	-10-2, pp 2-54, 58 & 66 -23-3, p 9-60 -23-4, p 17-2 -23-5, pp F-109 & 113	
Oil Level Check Lights Power Overdraw - OIL CHK LTS	Tripped Crcr Brkr (CB 146)			Cabin & Ramp Lts sw at White	>10 amps to sys- tems except red lights, K201 and K300. Same power source.	-10-2, pp 2-54, 58 & 67 -23-3, pp 9-65/66 -23-5, p F-104	
Engine Macelle Work Lights Pwr Overdraw - ENG MAC LTS	Tripped Crcr Brkr (CB 164)	5		All	>5 amps to oper- ating lights from the 28 VDC Battery Bus	-10-2, pp 2-54, 58 & 67 -23-3, p 9-64 -23-5, p F-112	

Table: A5 Electrical (Cont'd)

Sheet No.: 19

PARAMETER NAME - INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
	TYPE	RANGE	MARKINGS			CONDITION TYPE	DURATION		
Troop Jump Lgts Pwr Overdraw - TROOP ALARM JUMP LTS	Tripped Crcr Brkr (CB 1004)		5		>5 amps to lights from the 28 VDC Battery Bus			-10-2, pp 2-18, 56 & 58 -23-3, pp 9-60/62 -23-5, p F-165	
Troop Jump Alarm Bells Power Overdraw - TROOP ALARM BELL	Tripped Crcr Brkr (CB 1002)				>5 amps to bells from the 28 VDC Battery Bus				
Fire Extinguisher Control Relay (K127) & Fire Bottle Valves Supply Pwr Overdraw - FIRE EXT	Tripped Crcr Brkr (CB 1000)		10		>10 amps to relay and all activated valves from the 28 VDC Primary Bus				
Fire Bottle #1 (2) Individual Valve Power Overdraw - BOTTLE NO. 1 FMD (AFT) VALVE	Tripped Crcr Brkr (CB 706 & CB 702)			All	>5 amps to the activated valve, through the FIRE EXT circuit brkr (CB 1000)			-10-2, pp 2-16/18, 56 & 59 -23-4, p 12-14 -23-5, pp F-157 & 163	16
BOTTLE NO. 2 FMD (AFT) VALVE	Tripped Crcr Brkr (CB 704 & CB 700)								
Engine #1 (2) Fire Detection System Control Unit, Sensing Element and T Handle Lgts Pwr Overdraw - FIRE DET ENG NO. 1 (2)	Tripped Crcr Brkr (CB 1008 & CB 1006)		5		>5 amps to respec- tive system from the 115 VAC Primary Bus			-10-2, pp 2-16, 53 & 56 -23-4, p 12-8 -23-5, pp F-156/157	

Table: A5 Electrical (Cont'd)

Sheet No.: 20

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	PARAMETER		REFERENCES (TM 55-1520-227)	NOTE # (SH 21)
	TYPE	RANGE	MARKINGS		CONDITION	CONDITION TYPE - DURATION		
Self Tuning Dynamic Absorber System Pwr Overdraw - VIBRATION ABSORBERS LEFT (CTR & RIGHT)	Tripped Crc't Brkr (CB 1083, CB 1085 & CB 1081)		7.5		>7.5 amps to the re- spective absorber from the 115 VAC Primary Bus		-10-2, pp 2-10, 52 & 55 -23-1, p 2-188 -23-5, p F-132	
APU Relays K1- K6, No. 1 & 2 Flight Control Pump Solenoids, APU Fuel Boost Pump, APU Start Valve Solenoid, APU Start Fuel Valve Solenoid, APU Main Fuel Valve Solenoid, APU Fuel Valve Solenoid, APU Motor Valve Solenoid, APU Igniter, APU Warning Lights and APU Hour Meter Power Overdraw - APU	Tripped Crc't Brkr (CB 186)		10	Amps	APU SW at STOP, GND APU- AGB SW at NORM	>10 amps to the press to test warn. lgts (norm. put) from the 28 VDC Battery Bus	-10-2, pp 2-56, 58, 60 & 61 -23-4, pp 15-1/2 & F0-42 -23-5, pp F-123/125	17
					APU SW at STOP, GND APU- AGB SW at START	>10 amps to systems above & No. 1 Flgt Cntrl Valve Solen- oid. Same power source. (See note.)		
					APU SW at APU, APU not running	>10 amps to OVSP & HIGH EXH TEMP warn. lgts & LOW OIL PRESS warn. lgt if lit (norm. out) Same power source.		
					APU SW at APU, APU running	>10 amps to relays K3, K4, K5, the Main Fuel Valve & APU Fuel Valve solenoids, the APU Fuel Boost Pump & the APU Hour Meter. Same power source.		
					APU SW at START, APU <90%, Fuel pres- sure <110 psi	>10 amps to all components except the warn. lgts (as- sumed off), main fuel valve solen- oid & the igniter. Same power source.		
					APU SW at START, APU <90%, Fuel pres- sure >110 psi	>10 amps to all components except the warn. lgts (as- sumed off) & relay K1. Same power source.		

## NOTES:

1. Sensors are step down current transformers, contained in the respective generator control panel (A517 & 514 - note that throughout this table, a 114ES249 series control panel is assumed in use). The overvoltage time delay decreases linearly with increased output voltage (0.115 seconds for 180 vac). Normal voltage phase to ground is 120 vac (regulated to 115 vac) and phase to phase is 208 vac (regulated to 200 vac). The under frequency protection circuit reconnects the generator to the load if the output frequency rises back above 360 Hz. The undervoltage protection circuit reconnects the generator to the load if the 3 phase average voltage climbs to 104 vac, unless a lockout has been applied by the underfrequency circuit. The feeder protection senses current differences between the phase feeder and ground return lines.
2. Sensors are transformer (T213 & T215) which electromagnetically couple the loadmeters to the B phase power leads of generators #1 and #2. The units on the loadmeters are fractional loads, where 1.0 is 100% of the generator continuous load rating. The cautionary conditions were deduced on the basis that the continuous load should not exceed 100% of the rated load with the generator on line, if the generator is off line, the only load possible should be B phase sensing at the generator control panel.
3. Sensor is a Phase Sequence Network which checks the external power for proper phase sequence and activates relay K113 which delivers power (through contacts of relays K109 & K111) to the Gen. No. 1 Ext Pwr Relay (K101). K101 then connects the external power to the AC Primary Bus, and through a separate set of contacts, grounds the caution panel sensing lead which lights the light.
4. Sensors are low impedance shunts which produce a voltage sensed and displayed by the millivoltmeter type indicators. Loadmeter units are fractional loads like the AC loadmeters, where 1.0 load is 200 amperes (full rated load) and 300 amperes is a 1.5 load.
5. Sensors are REV CUR CO. Relays K128 and K126 respectively, which trip the corresponding XFMR-RECT FAILURE Relays (K118 & K120). These relays have contacts which ground the caution panel sensing lead which actuates the proper light.
6. Sensor is a blocking diode (CR 100, TM 47) which, for external voltage of the correct polarity, provides a current path for the coils of EXT PWR CONT Relay (K122). A pair of contacts for this relay closes a path to ground for the caution panel sensing lead which operates the light.
7. There are two circuit breakers for each of the three inter-bus feeder lines. Hence CB 1031 and C199 protect the same line and so forth for the other two lines and four breakers. The A PH FDR breakers are on the AC circuit Breaker Box and other breakers are on the overhead breaker panel.
8. Arrangement similar to that described in Note 7 above.
9. Power is supplied to the brake when the trigger switch is not engaged.
10. A caution on page 2-21 of the Operator's Manual notes that these circuit breakers must be in, otherwise the anti-ice will be on, degrading engine performance.
11. Note that these breakers are not shown on the typical overhead breaker panel illustrations of p 2-56 (Operator's Manual) and pages 9-93/95 of TM 55-1520-227-23-3.
12. The boost pumps are AC powered, via relays which are actuated by fuel boost pump switches in the overhead fuel panel. These switches route 28 vdc power to the relays. Specific signal routing is shown in the -23-5 reference figures. The indicator lights are not in the cockpit.
13. The valves are electrically actuated by the No. 1 (2) Engine Emergency T-Handle switches, S140 & S187. The indicator lights are not in the cockpit.
14. Power is routed to the amplifiers via the SAS Emergency Release Switch.
15. Power is supplied to the actuators/brake when the release button is engaged.
16. These circuit breakers are on a box located at station 534, on the overhead structure.
17. Since the position of the GND APU-AGB switch is not included in all of the operating modes listed, it should be noted that anytime the switch is in the start position, the additional load of the No. 1 Flight Control Valve solenoid is applied through the circuit breaker.

# SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: CH-47C

SUBSYSTEM: Miscellaneous

Table: A6

Sheet No.: 1

PARAMETER NAME - INDICATOR LABEL	TYPE	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		REFERENCES (TM 55-1520-227)	NOTE # (SH 3)
		RANGE	MARKINGS	UNITS			CONDITION TYPE	DURATION		
Longitudinal Cyclic Trim Actuator Position -  CYCLIC TRIM ACT-FWD (AFT)	Circular Dials (2)	0-160	--	KTS	0-60 KIAS	≤60	Normal - continuous		-10-2, pp 2-38, 5-17 & 9-14 -23-3, p 8-43 -23-4, p 11-230 -23-5, p F-41	1
SAS Amplifier Power Interruption or Disengagement - MO. 1 (2) SAS OFF	Caution Lgts (2)	--	Amber	--	All	1. AC or DC power failure to amplifiers 2. <2000 psi hy- draulic pres- sure to the No. 1 or No. 2 hy- draulic sys. respectively	Cautionary - unspecified		-10-2, pp 2-36, 56, 71, 5-18 & 9-14 -23-3, pp 9-98/99 & F0-14 -23-5, pp F-45 & 49	2
						DC power inter- rupted by EMER SAS REL switch	Advisory - unspecified			
						1. SAS sw moved to different positions 2. HYD BST sw moved to dif- ferent positions	Normal - transient			
						>177 (see note)				
Heater Output Temperature - HEATER HOT	Caution Lgt	--	Amber	°C	Heater on	>177 & heating sw at HEATER ON,	Cautionary - unspecified		-10-2, pp 2-49 & 71 -23-4, pp 13-1 & 7 -23-5, p F-77	3
					Heater off due to shutdown	2. <177 & HEATER START button not pushed or heat- ing sw at HEATER ON				

Table: A6 (Miscellaneous - Cont'd)

Sheet No.: 2

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		NOTE # (SH 2)
	TYPE	RANGE	MARKINGS			CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-227)	
Right Aft Steerable Landing Gear Swivel Angle - WHEEL DEPHASED	Caution Lgt	--	Amber	Lft turn (clock- wise swivel)	>62.5	Cautionary - unspecified	-10-2, pp 2-7 & 70 -23-3, pp 7-253/254 & FO-19 -23-5, p F-128	4
				Rt turn (ccw swivel)	>91			
Parking Brake Valve Plunger Position - PARK BRAKE ON	Caution Lgt	--	Amber	Air- craft on ground, no taxi	Plunger position is such as will trap fluid for parking brake actuation	Advisory - unspecified	-10-2, pp 2-7/9 & 10 -23-3, pp 7-268 & 277 -23-5, pp F-128	5
				Air- craft ground taxiing or in flight		Cautionary - unspecified		
Cargo Hook Position - CARGO HOOK OPEN	Caution Lgt	--	Amber	All	Cargo hook is in OPEN position	Cautionary - unspecified	-10-2, pp 2-71 & 4-21/25 -23-4, pp 16-142/144 -23-5, p F-119	6

## NOTES:

1. Sensors are (most likely) variable resistors which are built into both the forward pylon actuator and aft pylon actuator. The wiper of the resistor is mechanically driven by the actuator's dc servo motor and the resistor is electrically connected to the speed trim amplifier which in turn supplies the drive signal for the indicators. For operations at airspeeds above 60 KTS with the indicator showing 0-60 KTS, the maximum allowable airspeed is obtained from Figure 5-11, p 5-17 of the Operator's Manual.
2. Sensors are the No. 1 and No. 2 SAS amplifiers themselves, sensing vac, vdc, and No. 1 and No. 2 hydraulic system pressures. The activation of the capsule segments is accomplished by applying a ground to the appropriate line running to the caution panel. In addition the EMER SAS REL switch applies a ground to both of these lines when in the RELEASE position. Power to the capsule segments is most likely supplied by the DC Primary Bus through the CAUTION LIS circuit breaker on the overhead panel. Airspeed limit with one SAS on line is Vne or 120 KTS (if lower). Airspeed limits with both SAS off line below 120 KTS is Vne if Vne < 120 KTS.
3. Sensor is a thermoswitch (A209) which opens at 177°C removing power from relay K209 which shuts down the fuel control and ignition circuits while completing the grounding circuit for the caution light. The requirements for lighting the light are that K209 be deenergized and relay K205 be energized, which is accomplished by leaving the heating switch in the HEATER ON position.
4. Sensor is a cam actuated microswitch which simultaneously disables the power steering while turning on the caution light. The limits used are explained on the referenced page 7-253 and differ from those given in the Operator's Manual, these latter, being mean angular swivel values for the power steering tolerance zones. The disabling limits which are used in this A6 table are the wheel "out-of-zone" buffer zone extreme limits.
5. Sensor is most likely a position sensitive switch, linked to the parking brake valve pressure actuated plunger. Thus the switch may be indirectly referred to as pressure sensitive, although it is unclear whether loss of brake pressure would release the plunger and result in a state change of the switch and parking brake lever. Caution light activation is through grounding of the caution panel sensing lead.
6. Sensors are two position sensing switches. Switch S403 senses the hook rotating cam position, as operated by the manual emergency release. Switch S405 senses the hook actuating cylinder position, as operated by the normal hydraulic or emergency air release modes. Either switch provides a grounding path for the caution panel sensing lead.

HELICOPTER: CH-47C

SUBSYSTEM PARAMETER DATA LIST

Table: A7  
Sheet No.: 1

SUBSYSTEM: Auxiliary Power Unit (APU: T-62T-2A Type)

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		REFERENCES (TM 55-1520-227)	NOTE # (SH 2)
	TYPE	RANGE	MARKINGS			CONDITION TYPE - DURATION			
Turbine Speed - APU TACHOMETER	Circular Dial	0-110	--	APU SW at START	90	Maximum (release APU switch) - transient		-10-2, pp 2-60/61, 5-1, 8-5/6.1 -23-4, pp 15-1/3, 13 & F0-42 -23-5, p F-123/125	1
					90-98	Cautionary - transient			
					98-106	Normal - continuous (5 to 15 seconds after start initiated)			
					106-110	Cautionary - transient			
OWSP	Warning Lgt (Press to Test)	--	Red	APU is on	>110	Maximum - transient			2
					>110	Maximum (overspeed) - unspecified (see note)			
Exhaust Gas Temperature - HIGH EXH TEMP	Warning Lgt (Press to Test)	--	Red	APU is on	>(577-582)	Maximum (overtemp) - unspecified			3
Low Oil Pressure - LOW OIL PRESS	Warning Lgt (Press to Test)	--	Red	APU is on	<(5-7)	Minimum - unspecified			4



Table: A7 (APU - Cont'd)

Sheet No.: 2

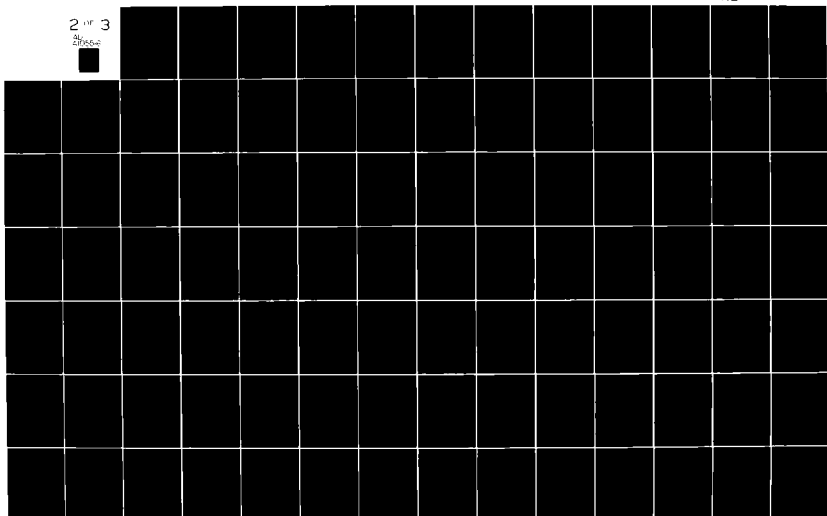
NOTES:

1. Sensor is a tachometer generator, mounted on and driven by the APU speed switch. The 3 phase AC output voltage is proportional to the APU turbine speed. The APU speed should stabilize in the 98-106% range 5-15 seconds after start is initiated.
2. Sensor is an overspeed switch which deenergizes the overspeed switch relay (K5), thereby simultaneously turning on the light and removing power from the APU main fuel valve solenoid, which shuts down the APU. The overspeed duration is unspecified, since shutdown commences simultaneously with the warning light activation. However, should the light activate and the APU not shut down, the 5 second overspeed limit should be observed and the APU should be shut down manually. The light will also illuminate when the APU is shut down and the switch is in the APU position.
3. Sensor is a thermoswitch which deenergizes the high exhaust gas temperature relay (K4) thereby simultaneously turning on the light and shutting down the APU as described in Note 2 above. The first page reference says the switching threshold is  $582^{\circ} \pm 6^{\circ}\text{C}$  for a T62-1-2A1 type APU, but the page 15-1 reference lists two thresholds: the one which is used on sheet 1 of this table plus a  $560^{\circ}\text{--}577^{\circ}\text{C}$  range for an unspecified type of APU. The light is also on when the APU is not running and the switch is in the APU position.
4. Sensor is a pressure switch which deenergizes the low oil pressure relay (K3) thereby simultaneously turning on the light and shutting down the APU in the manner described in Note 2 above. The light does not come on if the APU is shut down and the switch is in the APU position.

AD-A105 516 GENERAL ELECTRIC CO BIRMINGHAM N Y AIRCRAFT EQUIPMENT DIV F/6 1/3  
ELECTRONIC MASTER MONITOR AND ADVISORY DISPLAY SYSTEM. OPERATIO--ETC(U)  
OCT 80 DAAK80-79-C-0270  
UNCLASSIFIED ACS-12-217 USAAVRADCOM-TR-79-0270-2 NL

2 of 3

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SUBSYSTEM PARAMETER DATA LIST  
FOR THE  
UH-60A

SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: UH-60A

Table: B1

SUBSYSTEM: Engine

Sheet No.: 1

PARAMETER NAME - INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-237)	NOTE # (SH 4)
	TYPE	RANGE	MARKINGS					
Engine Power Turbine Speed - % RPM 1 (2)	Segmented Vertical Light Bar (Part of Engine/ Rotor Tachometer)	0-130	(0-91)R (91-96)A (96-101)G (101-105)A (105-130)R	All	91	Minimum - none except transients and idle (how- ever, operation in 25-40% and 60-75% range is pro- hibited).		
					91-96	Cautionary - transient	-10, pp 2-32, 5-2 & 5-6	1
					96-101	Normal - continuous	-23-2, pp 6-69, 12-5 & 14-1	
					101-105	Cautionary - 30 minutes	-23-3, pp 46-24/25	
					105-107	Warning - transient (12 sec)		
					107	Maximum - 12 sec		
Engine Gas Producer Speed - Mg SPEED 1 (2)	Segmented Vertical Light Bar w/Digital Readout	0-110	(0-98)G (98-102)A (102-110)R	Eng Cond Lever in IDLE, Eng Started  Eng Cond Lever in FLY, Eng Started	52-55	Normal - continuous	-10, pp 5-4 -23-2, pp 3-16, 6-68 & 13-1	2
					52-98	Normal - continuous		
					98-102	Cautionary - 30 minutes		
					102-105	Warning - transient (12 sec)		
					105	Maximum - 12 seconds		
#1(#2) ENG OUT	Master Warning Lights (2)		Red  --	All	<55	Warning (possible flame out) - continuous	-10, p 2-57 -23-2, pp 6-69, 6-78 & 13-3 -23-3, pp 46-5, 24, 25 & 31	3
	Steady Tone in ICS				0-775	Normal - continuous		4
					775-850	Cautionary - 30 minutes	-10, p 5-3 -23-2, pp 3-13, 6-68, 12-1 & 13-1	
					850-886	Warning - Transient (12 sec)		
					886	Maximum - 12 seconds		
Engine Turbine Gas Temperature - TGT TEMP 1 (2)	Segmented Vertical Light Bar w/Digital Readout	0-950	(0-775)G (775-850)A (850-950)R	All				

Table: 81 (Engine - Cont'd)

Sheet No.: 2

PARAMETER NAME - INDICATOR LABEL	TYPE	INDICATOR		OPERATING MODE	PARAMETER		REFERENCES (TM 55-1520-237)	NOTE # (SH 4)
		RANGE	MARKINGS		CONDITION	CONDITION TYPE - DURATION		
Engine Torque - % TORQUE 1 (2)	Segmented Vertical Light Bar w/Digital Readout	0-150	(0-100)G (100-110)A (110-150)R	Dual Engine	0-100	Normal - continuous	-10, pp 2-25, 5-2, 5-6, 7-4/9 -2-2, pp 3-16, 6-69, 12-5 & 14-1	5
					100-110	Cautionary - transient (10% - dual engine xmsn limit)		
					110-135	Warning - transient (10 sec)		
				Single Engine	135	Maximum - 10 seconds		
					0-110	Normal - continuous		
Engine Oil Temperature - ENG OIL Temp 1 (2)	Segmented Vertical Light Bar	-40-180	(-40-135)G (135-150)A (150-180)R	All	110-135	Warning - transient (10 sec limit but single eng. xmsn limit is 11%)	-10, pp 2-24 & 5-4 -23-2, pp 3-13, 6-68 & 13-1	6
					135	Maximum - 10 seconds		
					-40-135	Normal - continuous		
#1(2) ENGINE OIL TEMP	Caution Lights (2)		Amber	All	135-150	Cautionary - 30 minutes	-10, pp 2-60, 2-62 -23-2, pp 3-15, 3-18, 6-69, 6-75/76 & 13-3 -23-3, pp 11-10 & 58-4/7	7
					150	Maximum - 30 minutes		
					>150	Cautionary - unspecified (see above)		
Engine Oil Pressure - ENG OIL PRESS 1 (2)	Segmented Vertical Light Bar	10-130	(10-25)R (25-45)A (45-100)G (100-130)R	All	25	Minimum - see below	-10, pp 2-24 & 5-4 -23-2, pp 3-15/17, 12-1/4 & 13-1 -23-3, pp 11-9, 12-9 & 46-24/25	8
					25-45	Idle (Ng < 85%) - continuous		
					45-100	Normal (Ng ≥ 85%) - continuous		
					100	Maximum - continuous		

Table: B1 (Engine - Cont'd)

PARAMETER NAME - INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		NOTE # (SH 4)
	TYPE	RANGE	MARKINGS			UNITS	CONDITION TYPE - DURATION	
Engine Oil Pressure - #1 (2) ENGINE OIL PRESS	Caution Lights (2)		Amber	psi	All	<25	-10, pp 2-21, 2-24, 2-60/62 -23-2, pp 3-15 & 18, 6-69, 6-75 & 13-1 -23-3, pp 46-24/25	9
Engine Power- train/Gearbox Integrity - CHIP #1 (2) ENGINE	Caution Lights (2)		Amber	--	All	Sensor contacts grounded by metal particles from engine gearing	-10, pp 2-22, 2-60 & 62 -23-2, pp 3-18 & 6-75/76	10
Engine Oil Filter In/Out Differential Pressure - #1 (2) OIL FLTR BYPASS	Caution Lights (2)		Amber	psi	All	Oil pressure dif- ference between filter inlet and outlet is 60 to 80	-10, pp 2-21 & 2-61 -23-2, pp 3-18 & 6-75/76 -23-3, pp 11-11/12, 12-11/12, 58-5 & 58-9	11
Engine Anti-Ice/Start Bleed Valve Position - #1 (2) ENG ANTI-ICE ON	Advisory Lgts (2)		Green	--	Ng > (86- 87%) & Eng Anti- Ice SW on	Valve is open	-10, pp 2-21 & 63 -23-2, pp 3-18/19 & 6-77 -23-3, pp 17-1/8 & 58-7/9	12
ENGINE INLET TEMPERATURE - #1 (2) ENG INLET ANTI-ICE ON	Advisory Lgts (2)		Green	°C	All	Inlet temperature is above 200°F	-10, pp 2-22, 60, 62 & 8-8/9 -23-2, pp 3-8/12 & 6-75/76 -23-3, pp 16-1/14 & 58-6/7	13
Engine Start Control Valve Position - #1 (2) ENGINE STARTER	Caution Lgts (2)		Amber	--	Eng Start, Ng < (52-55%) Other than Eng. Start	Valve is open	-10, pp 2-22, 60, 62 & 8-8/9 -23-2, pp 3-8/12 & 6-75/76 -23-3, pp 16-1/14 & 58-6/7	14

Table: B1 (Engine - Cont'd)

NOTES:

1. Sensor is a tachometer type whose variable frequency output is converted to a d.c. voltage by the SDC (Signal Data Converter) Interface No. 2 module.
2. Same type of sensor as note 1 above, with conversion via the SDC Interface No. 1 module.
3. The signal is derived from the Ng speed sensor described above, via the SDC. The SDC provides signals to the voltage regulator card of the CDU (Central Display Unit) which then outputs the signals which actuate the warning lamps. The signals are routed back through the SDC connectors (but are not conditioned by the SDC) and then directly to the capsules in the pilot's and copilot's master warning panel and to the LH relay panel for routing to the ICS.
4. Seven alumel-chrome thermocouple probes provide direct temperature sensing. Their outputs are averaged and routed to the SDC which first compensates for ambient temperature changes and then conditions the signal at the SDC Interface No. 4 module before routing to the CDU for display.
5. The sensor is of an unspecified type which provides a signal, proportional to the amount of twist on the power turbine shaft, to the SDC Interface No. 2 module.
6. A variable resistance type sensor is used, the output of which is transformed into a d.c. voltage by the Interface No. 2 module of the SDC.
7. Using the same sensor signals as above, the signal to the caution panel is produced by the CDU Voltage Regulator and routed to caution/advisory panel channel cards A1 and A2, via the SDC connectors (although the SDC does not operate on the signal).
8. Sensor output is 400 Hz ac voltage which is routed to the SDC Interface No. 4 module. It is combined there with a 10 vac 400 Hz reference (from the logic power supply) to produce a d.c. voltage proportional to the engine oil pressure, which is then routed to the CDU for display.
9. The sensor is the same as for the note above. However, when this signal reaches the CDU it is routed to the Voltage Regulator (as well as to the actual oil pressure display units) which conditions and compares the signal to determine when a low oil pressure condition exists. The output signal resulting from that comparison is then routed to caution/advisory panel cards A1 and A2, via the SDC connectors (although the SDC does not operate on the signal).
10. Sensors are contacts, one of which is connected to ground and the other is wired to caution/advisory panel card A3. The contacts are bridged by metal chips and the ground sensing (with subsequent capsule illumination) is performed inside the panel, presumably by the card.
11. Sensors are pressure switches connected to caution/advisory panel cards A1 and A2.
12. Sensors are switches which are either on or off depending on the valve position. Routing of the #1 (2) signals is through caution/advisory panel cards A2 and A3 respectively.
13. Sensors are temperature sensitive switches wired to caution/advisory channel card A3. Although there is no duration specified in the manuals listed, additional checking should be done to confirm no limitation is imposed due to a high O.A.T.
14. Sensors are switches which detect start control value position. Wiring for #1 (2) switch is through caution/advisory panel channel card A1 (A2).

SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: UH-60A

Table: 82

SUBSYSTEM: Fuel

Sheet No.: 1

PARAMETER NAME - INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		NOTE # (SH 2)
	TYPE	RANGE	MARKINGS			CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-237)	
Fuel Qty, Left & Right Tanks - FUEL QTY (1 & 2)	Segmented Vertical Light Bar w/Digital Readout	0-1500	(0-200)A (200-1500)G	lbs	A11	0-200  200-1500	-10 pp 2-26, 5-5 & 8-7 -23-2 pp 3-20/26, 6-68, 12-1 & 4, 13-1, 5 & 6 -23-3 pp 23-3&8	1
#1(2) FUEL LOW	Flashing Caution Lgts (2)		Amber	lbs	A11	<(170-180)	-10, pp 2-26, 2-60 & 62 -23-2, pp 3-27, 6-75/ 76 & 15-4 -23-3, pp 22-1/6 & 58-4	2
Engine Fuel Filter Differential Pressure - #1(2) FUEL FLTR BYPASS	Caution Lgts (2)		Amber	psi	A11	$\geq 7.5$	-10, pp 2-25, 2-60 & 62 -23-2, pp 3-16, 6-75/ 76 & 15-1/3 -23-3, pp 11-11/12, 12-11/12 & 58-5/7	3
Engine Boost Pump Output Pressure - #1(2) FUEL PRESS	Caution Lgts (2)		Amber	psi	A11	$\leq 8.5 \pm 0.5$	-10, pp 2-19 & 2-60/ 62 -23-2, pp 3-16, 6-75/ 76 & 15-1/3 -23-3, pp 11-10, 12-10, & 58-6/7	4
Fuel Pump Sw & APU T-Handle Sw Positions - PRIME BOOST PUMP ON	Advisory Lgt		Green	--	A11	Fuel pump switch in either "Fuel Prime" or "APU BOOST" position & APU T-handle switch in the normal-closed position (T-handle not pulled)	-10, pp 2-26 & 2-63 -23-2, pp 3-20/23 & 15-1 -23-3, pp 21-5/6 & 58-9	5
Fuel Qty Front (1) & Rear (2) Aux. Tanks - AUX FUEL QUANTITY	Digital w/three position selector switch (No. 1, No. 2 & Total)	0-5200	N/A	lbs		>400 lbs per main tank 0-2600 (single tank) or 0-5200 (both tanks)  <400 lbs per main tank 0-2600 (single tank) or 0-5200 (both tanks)	Normal - continuous  Cautionary - see note	6
NO. 1 (2) AUX EMPTY	Warning Lgts (2)		--	lbs	A11	<10 per tank	-10, pp 2-26/28 & 6-8/9 -23-3, pp 1-9/11	7



Table: B2 (Fuel - Cont'd)

NOTES:

1. Sensors are capacitance type probes powered by 6 KHz a.c. voltage, through normally closed contacts of the FUEL IND TEST pushbutton switch. The a.c. current probe output is routed to a signal conditioner (where the 6 KHz signal also comes from) which transforms it to a d.c. voltage. This signal is then routed through the SDC (which does not operate on it) to the CDU Interface No. 2 module, along with the analog reset and multiplex signals from the SDC Analog Processor No. 2 module. The signal is then fed to the appropriate indicator. Need clarification of what is actual usable fuel capacity in each tank, since TM 55-1520-237-2, para. 3-34 says it's "about 177 gallons (1155 pounds)" and TM 55-1520-237-10 para. 2-73 says it's "about 181 US gallons of usable fuel".
2. Sensor is a set of thermistor "beads" at the bottom of each fuel probe. When the beads are no longer wet, the signal applied to the Low Level Warning Conditioner causes the output of that device to go low, which activates the flashing circuit on caution/advisory panel channel card A4. The fuel range threshold given in TM 55-1520-237-10 was 170-190 lbs., while TM 55-1520-237-23-2 said activation occurred at 172 lbs. of fuel. Finally, TM 55-1520-237-23-3 consistently used 170-180 lbs. as the threshold condition. This last reference was used since this would be the range maintenance personnel would refer to.
3. Sensors are pressure switches with outputs wired to caution/advisory panel channel cards A1 and A2. Switches are an integral part of the fuel filter assembly.
4. Sensors are pressure switches with outputs wired to caution/advisory panel channel cards A1 & A2.
5. Sensor consists of switch S102 (which is connected to the APU T-Handle) wired in series with one part of switch S19, the Fuel Pump switch. When these switches are closed, 28 vdc is routed to the advisory light through the control/advisory panel channel card A3.
6. Sensors are similar to those in Note 1 above. The indicator is located on the lower portion of the Range Extension Control Panel. Signal processing is accomplished within this panel. The cautionary condition depends upon a number of variables: actual fuel weight in all four tanks, fuel transfer rate, additional weight in aircraft due to crew, equipment, etc., all of which can vary according to mission type and phase.
7. Sensors are of the type described in Note 2 above. The indicators are positioned on and the signals are processed within the Range Extension Control Panel.

HELICOPTER: UH-60A

SUBSYSTEM: Powertrain (Includes Main and Tail Rotor Groups)

SUBSYSTEM PARAMETER DATA LIST

Table: B3

Sheet No.: 1

PARAMETER NAME - INDICATOR LABEL	INDICATOR			OPERATING MODE	PARAMETER			NOTE # (SH 4)
	TYPE	RANGE	MARKINGS		CONDITION	CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-237)	
Main Rotor RPM - % RPM R	Segmented Vertical Light Bar	0-130	(0-91)R (91-96)A (96-101)G (101-122)A (122-130)R	Powered Flight	91	Minimum - transient and idle only	-10, p 5-2 -23-2 pp 6-69 & 14-1	1
					91-96	Cautionary - transient		
					96-101	Normal - continuous		
				Power Off (Auto- rotation)	122	Maximum - unspecified		
					90	Minimum - continuous		
Main Rotor Overspeed - RTR OVERSPEED	Three Discrete Lights		Red	All	90-110	Normal - continuous	-10, p 5-2 -23-2, pp 6-68, 13-3 & 14-3 -23-3, p 46-3	2
					110-120	Cautionary - transient		
					120	Maximum - transient		
					> 127 > 137 > 142	Maximum RPM has been exceeded (lights will remain on until manually reset by maintenance personnel) - unspecified		
Main Rotor Speed Low - LOW ROTOR RPM	Steady tone in ICS Light on Master Wrng Panel		— Red	No weight on wheels All	< 95 (or 96)	Warning - unspecified (However see durations specified for Main Rotor RPM)	-10, p 2-63 -23-2, pp 6-69 & 78 -23-3, p 46-24	3
Main Transmis- sion Module Oil Temp - XMSN TEMP	Segmented Vertical Light Bar	-50 -170	(-50 -120)G (120-140)A (140-170)R	All	-50-120	Normal - continuous	-10, p 5-5 -23-2, pp 6-68 & 13-1	4
					120-140	Cautionary - transient		
					140	Maximum - transient		
MAIN XMSN OIL TEMP	Caution Lgt		Amber	All	> (112-121)	Cautionary - unspecified (see above)	-10, pp 2-36 & 60 -23-2, pp 4-11 & 6-75 -23-3, p 26-8 (note 4)	5

Table: B3 (Powertrain - Cont'd)

Sheet No.: 2

PARAMETER NAME - INDICATOR LABEL	TYPE	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		NOTE # (SH 4)
		RANGE	MARKINGS	UNITS			CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-237)	
Main Transmis- sion Module Oil Pressure - XMSN PRESS	Segmented Vertical Light Bar	0-190	(0-20)R (20-30)A (30-65)G (65-130)A (130-190)R	psi	All	20	Maximum - none allowed	-10, p 5-5 -23-2, pp 4-14, 6-68 & 13-1/6 -23-3, pp 26-7 & 46-25	6
						20-30	Cautionary - transient		
						30-65	Normal - continuous		
						65-130	Cautionary - transient		
						130	Maximum - transient		
MAIN XMSN OIL PRESS	Caution Lgt		Amber	psi	All	< (14 ±2)	Cautionary - unspecified (see above)	-10, pp 2-36 & 60 -23-2, pp 4-14 & 6-75 -23-3, p 26-8 (note 3)	7
Intermediate Tail Rotor Drive Gearbox Oil Temperature - INT XMSN OIL TEMP									
Tail Rotor Gearbox Oil Temperature - TAIL XMSN OIL TEMP	Caution Lgt		Amber	°C	All	>(134-146)	Cautionary - unspecified	-10, pp 2-36 & 61 -23-2, p 6-75 -23-3, p 26-8 (note 5)	8
Gearbox Integrity - CHIP MAIN MDL SUMP									
CHIP INPUT MDL - LH	Caution Lgts (7)							-10, pp 2-37, 2-60 & 2-62 -23-2, pp 6-75 & 6-77 -23-3, pp 27-7/8	9
CHIP INPUT MDL - RH									
CHIP ACCESS MDL - LH									
CHIP ACCESS MDL - RH									
CHIP INTM XMSN CHIP TAIL XMSN									
			Amber		All	Sensor contacts grounded by metal particles from gearbox	Cautionary - unspecified		

Table: B3 (Powertrain - Cont'd)

Sheet No.: 3

PARAMETER NAME - INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER CONDITION TYPE-DURATION	REFERENCES (TM 55-1520-237)	NOTE # (SH 4)
	TYPE	RANGE	MARKINGS					
Main Rotor Gust Lock Engagement - GUST LOCK	Caution Lgt		Amber	All	Rotor gust lock on	Cautionary - N/A	-10, p 2-61 -23-2, pp 4-17, 6-75 -23-3, pp 28-3/4	10
Tail Rotor Control Cable Integrity - TAIL ROTOR QUADRANT	Caution Lgt		Amber	All	Tail rotor cable broken	Cautionary - N/A	-10, pp 2-39 & 2-60 -23-2, pp 5-16 & 6-75 -23-3, p 30-4	11

Table: B3 (Powertrain - Cont'd)

NOTES:

1. Sensor is a tachometer or frequency transducer. Reduce the maximum rpm in autorotations at O.A.T. below  $-20^{\circ}\text{C}$  by  $1\frac{1}{2}/5^{\circ}$  reduction in O.A.T.
2. Same sensor as above but drive signal comes from SOC.
3. Light flashes at 3-5 Hz. The TM 55-1520-237-10 reference indicates the LOW ROTOR RPM light comes on "below about 95% rotor RPM, but all other references use the 96% figure as a threshold. Hence both numbers are included herein, and further clarification may be needed. Since 96% is at the bottom of the green segment on the % RPM R indicator, it is more likely that that is the correct number.
4. Variable resistance sensor output converted to d.c. voltage by the CDU Interface #2 module.
5. The sensor is a temperature switch wired to caution panel card A1. The first reference listed indicates that the caution light goes on when the oil temperature reaches  $121^{\circ}\text{C}$ . The second reference is "over  $112^{\circ}$  to  $121^{\circ}\text{C}$ ". The fourth reference says the light is on "above  $113^{\circ}$  to  $121^{\circ}\text{C}$  (235 $^{\circ}$  to  $250^{\circ}\text{F}$ )" and finally, the fifth reference says the "switch closes when temperature is above  $112^{\circ}$  to  $121^{\circ}\text{C}$ ". This last range was used in the tabulation since that reference is a maintenance trouble shooting manual, but the actual range should be clarified.
6. Sensor output is a d.c. voltage which is conditioned by the CDU Interface No. 1 module.
7. The sensor is a pressure sensitive switch wired to caution panel card A1. The first reference listed says that the caution light comes on when a "pressure drop" occurs at  $14 \pm 2$  psi. The second reference indicates that the light is on "below about 14 psi", the third reference says it occurs "below 14 psi" and the last two references say "below  $14 \pm 2$  psi". Although there is some uncertainty here, the  $14 \pm 2$  psi seems to be the most agreed upon threshold.
8. Sensor is a temperature sensitive switch connected to caution panel card A4. All references indicate the caution light goes on when the gearbox oil temperature is above  $140^{\circ}\text{C}$ , except the last reference, which says the threshold "is above  $134^{\circ}\text{C}$  to  $146^{\circ}\text{C}$ ". Since most sensors have a tolerance associated with the switching threshold, this last reference is assumed to be the most realistic of those available.
9. Sensors are connected to caution panel cards A3 and A4. The last reference shown indicates that the ground sensing circuitry which lights the caution capsules is actually integrated into the caution/advisory panel. The TM 55-1520-237-23-2 reference seems to indicate this circuitry is split between two cards; A3 (capsules 33, 74 and 75) and A4 (capsules 13, 14, 32 and 53). Also, knowledge of the fuzz burn-off circuitry is lacking and may be required. Finally, the reference indicates the CHIP MAIN MDL SMP capsule signal must be present for 30 seconds before the capsule is illuminated, but no explanation is given for why this is so.
10. Sensor is a microswitch connected to caution panel card A1.
11. Sensors are two microswitches in the tail rotor quadrant, connected to caution panel card A1.

SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: UH-60A

Table: B4

SUBSYSTEM: Hydraulic

Sheet No.: 1

PARAMETER NAME- INDICATOR LABEL	TYPE	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		NOTE # (SH 2)
		RANGE	MARKINGS	UNITS			CONDITION TYPE -	REFERENCES (TM 55-1520-237)	
Hydraulic Pump Pressure - #1 (2) HYD PUMP	Caution Lgts (2)		Amber	psi	All	< (2000 ±50)	Cautionary - unspecified	-10, pp 2-34/35 & 61 -23-2, pp 5-2/6 -23-3, pp 29-9 & 58-5	1
BACK UP PUMP ON	Advisory Lgt		Green	psi	All	> 2350	Advisory - unspecified (but see note)	-10, pp 2-34/35 & 63 -23-2, pp 5-6 & 6-77 -23-3, pp 29-28 & 58-9	2
Primary Servo Pressure (1st & 2nd Stage) - #1 (2) PRI SERVO PRESS	Caution Lgts (2)		Amber	psi	All	< (2000 ±50)	Cautionary - unspecified	-10, pp 2-60/62 -23-2, pp 5-2/6 & 6-75/76 -23-3, pp 29-30/34	3
Tail Rotor Servo Pressure (1st & 2nd Stage) - #1 TAIL RTR SERVO	Caution Lgt		Amber			< (2000 ±50)	Cautionary - unspecified	-10, pp 2-62/63 -23-2, pp 5-6 & 6-76/77 -23-3, pp 29-30/32 & 58-7/9	4
#2 TAIL RTR SERVO ON	Advisory Lgt		Green	psi	All	> 2350	Advisory - unspecified		5
Yaw & Collective Boost Servo Pressure - BOOST SERVO OFF	Caution Lgt		Amber	psi	All	Low pressure - see note	Cautionary - unspecified	-10, p 2-60 -23-2, pp 5-3/6, 5-14 & 6-75	6
Hydraulic Fluid Reservoir Low - #1 (2) RSVR LOW	Caution Lgts (3)		Amber	qt	All	< 0.6	Cautionary - unspecified	-10, pp 2-61/62 & 69 -23-2, pp 6-76/77 -23-3, pp 29-30/32 & 58-51	7
BACK-UP RSVR LOW									8

Table: B4 (Hydraulic - Cont'd)

NOTES:

1. Sensors are pressure switches attached to the #1 or #2 transfer module and wired to caution/advisory panel channel cards A1 and A2 respectively.
2. Sensor is a pressure switch attached to the utility module and wired to caution/advisory panel channel card A3. Although there is no caution given concerning a time limit on operation of the backup pump, TM 55-1520-237-23-3, p 29-1 contains a caution for ground maintenance run time not to exceed 30 minutes. Need to know if this limit applies only to operations with rotors not turning, all ground operations, etc.
3. Sensors are pressure switches attached to the lateral, forward and aft servos of the primary servo manifold, stages 1 and 2. The wiring is to caution/advisory panel channel cards A1 and A2.
4. Sensor is a pressure switch attached to the 1st stage position of the Tail Rotor Servo Cylinder. The signal to operate the light is routed, via the No. 1 Logic Module in the LH Relay Panel, to caution/advisory panel channel card A2.
5. Same sensor type as above but installed on the 2nd stage position of the Tail Rotor Servo Cylinder. The switch output is wired directly to caution/advisory panel channel card A3.
6. Sensors seem to be two pressure switches, mounted on the yaw and collective boost servos and wired to caution/advisory panel channel card A1. Sensor pressure threshold is not specified in the available sources. The most likely threshold is < (2000 ±50) psi since that is the pressure threshold for the #2 HYD PUMP caution light. Also TM 55-1520-237-23-3 p 65-1 step 7 indicates a pressure of 2000 psi at 2gpm on the yaw boost assembly activates a Boost Press Off light on the Pilot Assist/Nulling Test Box, which may be looking at the yaw boost pressure switch normally connected to the caution capsule.
7. Sensors are micro switches which detect the position of the pressure piston in pump reservoirs 1 and 2. The signals are routed, through Logic Modules 1 and 2 respectively, to caution/advisory panel channel cards A1 and A2.
8. Sensor is a micro switch coupled to the backup pump reservoir pressure piston position. The signal is routed through the No. 2 Logic Module and thence to caution/advisory panel channel card A2.

SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: UH-60A

Table: B5

SUBSYSTEM: Electrical

Sheet No.: 1

PARAMETER NAME - INDICATOR LABEL	INDICATOR			OPERATING MODE	PARAMETER		REFERENCES (TM 55-1520-237)	NOTE # (SH 20)
	TYPE	RANGE	MARKINGS	UNITS	CONDITION	CONDITION TYPE - DURATION		
Generator Output Suitability -					Volts out <100 $\pm$ 5 vac, volts out >125 $\pm$ 1 vac or feeder fault (unbalanced load)	Cautionary - unspecified		
#1 (2) GEN	Caution Lgts (2)		Amber	--	Volts out <100 $\pm$ 5 vac, volts out >125 $\pm$ 1 vac, freq. out <375 $\pm$ 5 Hz (1-3 seconds) or Feeder fault (unbalanced load)	Cautionary - unspecified	-10, pp 2-45/49 & 2-60/61 -23-2, pp 6-10/16 & 6-75/76 -23-3, pp 31-15/20 & 58-5	1
APU Generator Output & Connection Status -					100 $\pm$ 5 <Vout <125 $\pm$ 1 vac, Freq. out >375 $\pm$ 5 Hz, no Feeder fault, and GENERATORS APU Switch ON.	Advisory - unspecified	-10, pp 2-49 & 63 -23-2, pp 6-1/15 & 77 -23-3, pp 31-16/20 & 58-9	2
APU GEN ON	Advisory Lgt		Green	--				
Generator Main Bearing Wear -					Sensor ring embed- ded in bearing con- tacts outer face of the auxiliary bearing	Cautionary - unspecified	-10, pp 2-49, 60 & 61 -23-2, pp 6-11 & 6-75/76 -23-3, pp 58-9/10	3
#1 (2) GEN BRG	Caution Lgts (2)		Amber	--				
A.C. Essential Bus Status -					Bus disconnected from both No. 1 and No. 2 A.C. Primary Bus	Cautionary - unspecified	-10, pp 2-50/51 & 60 -23-2, pp 6-7, 13, 17 & 75 -23-3, pp 31-19 & 58-5	4
AC ESS BUS OFF	Caution Lgt		Amber	--				
External Pwr Re- ceptacle Connec- tion Pins -					Pins jumpered	Advisory - unspecified	-10, pp 2-49 & 63 -23-2, pp 6-7, 9, 14 & 77 -23-3, pp 31-18/19 & 58-9	5
EXT PWR CONNECTED	Advisory Lgt		Green	--				
D.C. Converter Output -					No output voltage	Cautionary - unspecified	-10, pp 2-45, 60 & 61 -23-2, pp 6-21/25 & 6-75/76 -23-3, pp 32-14/15 & 58-5	6
#1 (2) CONV	Caution Lgts (2)		Amber	--				



Table: B5 (Electrical-Cont'd)

Sheet No.: 2

PARAMETER NAME - INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		NOTE # (SH 20)
	TYPE	RANGE	MARKINGS			CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-237)	
D.C. Essential Bus Status - DC ESS BUS OFF	Caution Lgt		Amber	All	Bus has been dis- connected from No. 1 and No. 2 DC Primary Buses and from the BATT BUS	Cautionary - unspecified	-10, p 2-61 -23-2, pp 6-21/27 & 76 -23-3, pp 32-14/15 & 58-5	7
Low Battery Charge - BATTERY LOW CHARGE	Caution Lgt		Amber	All	<40	Cautionary - unspecified	-10, pp 2-45 & 60 -23-2, pp 6-18/26 & 75 -23-3, pp 32-14 & 58-5	8
Battery Over- charge & Over- temperature - BATTERY FAULT	Caution Lgt		Amber	All	Temperature >160°F and/or unbalanced cell voltage	Cautionary - unspecified	-10, pp 2-45 & 61 -23-2, pp 6-18/27 & 76 -23-3, pp 32-14 & 58	9
Engine Overspeed Protection Circuit Redundant Power Interrupted - NO. 1 (2) ENG OWSP	Tripped Crct Brkrs (CB 146, CB 244)		5		>5 amps redundant current to respec- tive engine ECU and/or history re- corder, from No. 1 or No. 2 AC Pri- mary Bus, respec- tively		-23-2, p 3-14 -23-3, pp 13-15/16	
DC Converted Power Interrupted - NO. 1 (2) CONVERTER	Tripped Crct Brkrs (CB 163 & CB 264)		20		>20 amps/phase to the applicable con- verter from No. 1 or No. 2 AC Pri- mary Bus, respec- tively		-23-2, p 6-24 -23-3, p 32-13	
#1 (2) SCD Power & Fuel Qty Sig Conditioner Pwr Interrupted - NO. 1 (2) AC INST	Tripped Crct Brkrs (CB 124 & CB 243)				>5 amps to the No. 2 SDC from the No. 2 AC Primary Bus through CB 243 and >5 amps to the No. 1 SDC and Fuel Quantity signal conditioner from the No. 1 AC Pri- mary Bus, through CB 124		-23-2, pp 6-66/67 -23-3, pp 31-21/22 & 46-24	
NO. 1 (2) DC INST	Tripped Crct Brkrs (CB 132 & CB 229)		5	All			-23-2, pp 6-66 -23-3, pp 32-16 & 46-24	
Backup Hydraulic Pump Motor Pwr - HYD PWR PUMP	Tripped Crct Brkr (CB 404)		40	All	>40 amps to pump motor from the No. 1 AC Pri- mary Bus		-23-3, pp 29-27 & 31-21	10

Table: 85 (Electrical-Cont'd)

Sheet No.: 3

PARAMETER NAME- INDICATOR LABEL	INDICATOR		OPERATING MODE		PARAMETER		REFERENCES (TM 55-1520-237)	NOTE # (SH 20)
	TYPE	RANGE	MARKINGS	UNITS	CONDITION	CONDITION TYPE - DURATION		
Range Extension Tank Pump Pwr - #1 (2) EXT RANGE PUMP	Tripped Crcr Brkr (TBD)		15		>15 amps to the respective pump from the No. 1 or No. 2 AC Primary Buses, respectively		-10, pp 2-48/51	11
	Tripped Crcr Brkr (TBD)		2		>2 amps to gauging unit from the No. 2 AC Primary Bus		-10, pp 2-48 & 51 -23-2, pp 1-9/11	
Provisional 60 Hz Converter Power - 60 HZ CONVERTER	Tripped Crcr Brkr (CB 161)		15	Amps	>15 amps to con- verter from the No. 1 AC Pri- mary Bus		-10, p 2-51 -23-3, pp 31-14 & 20	
AC Essential Bus Fail Relay Power - AC ESNTL BUS WARN	Tripped Crcr Brkr (CB 225)		5		>5 amps to relay from the AC Essential Bus		-10, pp 2-48 & 51 -23-2, pp 6-13 -23-3, p 31-19	
Stabilator Amplifier 115 VAC Power - STAB CONTR	Tripped Crcr Brkr (CB 145 & CB 242)		5		>5 amps to No. 1 and No. 2 ampli- fiers from the No. 1 and No. 2 AC Primary Buses, respectively		-10, p 2-33 & 51 (TM 11-1520-237) -23-1, pp 2-16 & 17 -23-2, pp 2-98 & 102	
Stabilator Con- trols/AFCs- Panel, Stabila- tor Amplifier, Stabilator Actuators and Stabilator Up-Down Limit Switch 28 vdc Power - STAB PMR	Tripped Crcr Brkr (CB 116 & CB 209)		7.5	Amps	>7.5 amps to indi- cated devices from No. 1 and No. 2 DC Primary Buses, respectively		-10, pp 2-33 & 47 (TM 11-1520-237) -23-1, pp 2-16 & 17 -23-2, pp 2-98 & 102	

Table: B5 (Electrical-Cont'd)

Sheet No.: 4

PARAMETER NAME- INDICATOR LABEL	TYPE	INDICATOR		UNITS	OPERATING MODE	CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-237)	NOTE # (SH 20)
		RANGE	MARKINGS						
Stabilator Position Transmitter and Indicators 26 vac Power - STAB IND	Tripped Crct Brkr (CB 218)		2			>2 amps to indicated devices from the 26 vac Essential Bus		-10, pp 2-34 & 51 (TM 11-1520-237) -23-1, pp 2-15 & 17 -23-2, pp 2-107	
Analog Stability Augmentation System (SAS1) Power - SAS AMPL	Tripped Crct Brkr (CB 217)		2			>2 amps, 115 vac to amplifier from AC Essential Bus		-10, pp 2-31/33, 41 & 51 (TM 11-1520-237) -23-1, pp 2-3, 6, 9, 12 & 13 -23-2, pp 2-94 & 100	
SAS BOOST	Tripped Crct Brkr (CB 313)		5			>5 amps, 28 vdc to amplifier, AFCS panel and SAS OFF caution light from DC Essential Bus			
Digital Auto. Fit Control Sys. (SAS2) Power Interrupted - CMPTR	Tripped Crct Brkr (CB 259)		2	Amps	All	>2 amps to computer and fan motors from No. 2 AC Primary Bus			
26V INST	Tripped Crct Brkr (CB 219)		2			>2 amps to the roll and yaw rate gyros from the 26 volt AC Essential Bus			
CMPTR TRIM	Tripped Crct Brkrs (CB 111 & CB 208)		7.5 & 5 (Resp.)			>7.5 (5) amps to the AFCS panel and SAS/FPS computer from the No. 1 (2) DC Primary Bus			
					Weight on wheels	>5 amps to systems listed above from No. 2 DC Primary Bus with the addition of power to self test circuitry in the computer			

Table: 85 (Electrical-Cont'd)

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-237)	NOTE # (SH 20)
	TYPE	RANGE	MARKINGS					
Pitot Heater Power Interrupted - LEFT (RIGHT) PITOT HEAT	Tripped Crc't Brkrs (CB 122 & CB 241)		10		>10 amps to left or right heater elements from No. 1 or No. 2 AC Primary Busses, Respectively		-10, pp 2-48 & 51 -23-2, pp 6-62 -23-3, pp 31-21/22 & 44-4	
Engine Inlet Anti-Ice Valve & Anti-Ice Start Bleed Valve Pwr Overdraw - NO. 1 (2) ENG ANTI-ICE	Tripped Crc't Brkrs (CB 135 & CB 234)		5		>5 amps to start bleed valves from No. 1 & No. 2 DC Primary Bus respec- tively. Also >5 amps to No. 2 Eng. Inlet Anti-Ice valve from No. 2 DC Primary Bus & >5 amps to Left & Right Pitot Heat caution capsules through CB 135		-10, pp 2-40, 47 & 51 -23-2, pp 3-19 & 6-62 -23-3, pp 16-13/14, 17-8, 44-4 & 32-13, 16	
Engine Anti-Ice On and Engine Inlet Anti-Ice On Advisory Cap- sules Power Interrupted - NO. 1 (2) ENG ANTI-ICE WARN	Tripped Crc't Brkrs (CB 134 & CB 233)			No. 1 Ng > 52% to 55%	>5 amps to the No. 1 Eng. Inlet Anti- Ice Valve from the No. 1 DC Primary Bus, thru CB 135			
Cargo Hook Re- lease Solenoid Pwr Overdraw - CARGO HOOK PWR	Tripped Crc't Brkr (CB 237)		5	All	>5 amps to the capsules from the No. 1 & No. 2 DC Primary Busses respectively			
					>5 amps to sole- noid from No. 2 DC Primary Bus		-10, pp 2-47 & 4-11 -23-2, pp 2-21/22 -23-3, pp 2-9/10	

Table: B5 (Electrical-Cont'd)

Sheet No.: 6

PARAMETER NAME - INDICATOR LABEL	INDICATOR			OPERATING MODE	PARAMETER		NOTE # (SH 20)
	TYPE	RANGE	MARKINGS		CONDITION	CONDITION TYPE - DURATION	
Cargo Hook Re- lease Control - Pwr Overdraw - CARGO HOOK CONT	Tripped Crc't Brkr (CB 238)		5	All Amps	>5 amps to cargo hook, anti cycling relay & HOOK ARMED advisory light (when arming sw is in ARMED posi- tion) & CARGO HOOK OPEN advisory light (when Hook Open sw, S2, or linkage safe switch S3 is open) from No. 2 DC Primary Bus	-10, pp 2-47 & 4-11 -23-2, pp 2-21/22 -23-3, pp 2-9/10	
Emergency Re- lease Cartridge & Test Circuitry Pwr Overdraw - CARGO HOOK EMER RLSE	Tripped Crc't Brkr (CB 306)		5		>5 amps to cir- cuitry and squib from DC Essential Bus		
Dimming Cir- cuitry, Instru- ment Panel & Console Lights, Parking Brake Light & Gust Lock Light Pwr Overdraw - LIGHTS ADVSY	Tripped Crc't Brkr (CB 140)		5		>5 amps to indi- cated systems from the No. 1 DC Primary Bus	-10, pp 2-11 & 47 -23-1, p 3-2 -23-2, pp 2-27 & 6-34 -23-3, pp 6-5 & 38-4	
Ventilation Blower Motor Pwr Overdraw - HEAT & VENT	Tripped Crc't Brkr (CB 263)		5		>5 amps to motor from No. 2 AC Primary Bus	-10, pp 2-43, 44 & 51 -23-2, pp 2-17 -23-3, pp 3-7/8, 16-13/14 & 31-22	

Table: B5 (Electrical-Cont'd)

PARAMETER NAME - INDICATOR LABEL	TYPE	INDICATOR		UNITS	OPERATING MODE	PARAMETER		REFERENCES (TM 55-1520-237)	NOTE # (SH 20)
		RANGE	MARKINGS			CONDITION	CONDITION TYPE - DURATION		
Ventilation Blower Motor Control Pwr Overdraw - HEAT VENT	Tripped Crc't Brkr (CB 213)		5		All	>5 amps to blower relay in RH Relay Panel, thru VENT BLOWER switch		-10, pp 2-43, 44 & 51 -23-2, pp 2-17 -23-3, pp 3-7/8, 16-13/14 & 31-22	
Engine Cross- bleed Valve or APU Bypass Valve and/or Mixing Valve Pwr Overdraw - AIR SOURCE HEAT START	Tripped Crc't Brkr (CB 155)		5	Amps	Air source HEAT/ START sw at ENG, HEAT sw OFF	>5 amps to No. 1 or No. 2 cross- bleed valve relay from No. 1 DC primary Bus			
					Air source HEAT/ START sw at ENG, HEAT sw ON	>5 amps to valves above plus Mixing valve			
					Air source HEAT/ START sw at OFF	>5 amps to Mixing Valve			
					Air source HEAT/ START sw at APU, HEAT sw OFF	>5 amps to APU start bypass valve relay (K22)			
					Air source HEAT/ START sw at APU, HEAT sw ON	>5 amps to relay K22 plus Mixing valve relay			

Table: 85 (Electrical-Cont'd)

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	PARAMETER		NOTE # (SH 20)
	TYPE	RANGE	MARKINGS		CONDITION	CONDITION TYPE - DURATION	
Windshield Wiper Motor Power Overdraw - WSHLD WIPER	Tripped Crcr Brkr (CB 159)		5		>5 amps to motor from No. 1 AC Primary Bus		-10, pp 2-39 & 51 -23-2, p 2-18 -23-3, pp 4-5/6 & 31-21
Windshield Anti- Ice Heating Ele- ment Power Overdraw - PILOT (CO- PILOT) WSHLD ANTI-ICE	Tripped Crcr Brkr (CB 261 & CB 160)		15		>15 amps to ele- ments or Anti-Ice Controllers from No. 2 & No. 1 AC Primary Busses respectively		-10, pp 2-39/40, 47, 48 & 50 -23-2, pp 6-48/50 -23-3, pp 5-7/8 & 31-32
Windshield Anti- Ice Controller Pwr Overdraw - PILOT (CO- PILOT) WSHLD ANTI-ICE	Tripped Crcr Brkr (CB 252 & CB 133)		5	All	>5 amps to the con- trollers from the No. 2 & No. 1 DC Primary Busses, respectively		
Windshield Anti- Ice Pwr Disable Relay (K21) Pwr Overdraw - APU GEN CONTR	Tripped Crcr Brkr (CB 10)		5		>5 amps to the relay from the Battery Bus		12
Chaff Dispenser Pwr Overdraw - CHAFF DISP	Tripped Crcr Brkr (CB 110)		7.5	Weight off wheels  Weight on wheels	>7.5 amps to Chaff Dispenser control panel & electronic module from No. 1 DC Primary Bus  >7.5 amps to in- hibit relay & in- hibitor electronic module		-10, pp 2-47, 48 & 4-1 -23-2, pp 2-25 -23-3, pp 9-5/6

Table: B5 (Electrical-Cont'd)

Sheet No.: 9

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		NOTE # (SH 20)
	TYPE	RANGE	MARKINGS			CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-237)	
Fuel Press, Fuel Filter Bypass & Engine Chip Cau- tion Lights Pwr Overdraw - NO. 1 (2) ENG WARN LTS	Tripped Crcr Brkr (CB 136 & CB 235)		2	All	>2 amps to lights specified from No. 1 or No. 2 DC Primary Busses, respectively		-10, pp 2-19, 26, 47 & 48 -23-2, pp 3-16 & 23 -23-3, pp 11-10/11, 12-10/11 & 15-5/6	
Engine Speed Trim Motor Pwr Overdraw - SPEED TRIM	Tripped Crcr Brkr (CB 210)		5		>5 amps to motor from No. 2 DC Primary Bus		-10, pp 2-33, 47 & 48 -23-2, p 3-12 -23-3, pp 14-6 & 32-16	
No. 1 Engine Inlet Anti-Ice Valve, Relay K45, #1 Engine Starter Caution Light, #1 Engine Start Control Valve & APU By- pass Valve Pwr Overdraw - NO. 1 ENG START	Tripped Crcr Brkr (CB 312)		5	Eng Start on APU, Ng <52%- 55%  Eng Start No APU, Ng <52%- 55%  All other condi- tions	>5 amps to systems from DC Essential Bus  >5 amps to all above except APU Bypass valve  >5 amps to cau- tion light, if lit (also possible pwr to start valve) or to APU Bypass valve if relay K22 is on Start switch in APU position or relay jammed)		-10, pp 2-22, 40, 47 & 51 -23-2, pp 3-11 & 19 -23-3, pp 16-13/14, 17-8	



Table: B5 (Electrical)-Cont'd)

PARAMETER NAME - INDICATOR LABEL	INDICATOR			PARAMETER			NOTE # (SH 20)
	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	
Relay K30, Starter Speed Sw, #2 Engine Starter Caution Light, #2 Engine Start Control Valve & APU By- pass Valve Pwr Overdraw - NO. 2 ENG START CONTR	Tripped Crcr Brkr (CB 236)				Eng Start on APU, Ing <52%- 55%	>5 amps to systems from No. 2 DC Primary Bus	-10, pp 2-22, 40, 47 & 51 -23-2, pp 3-11 & 19 -23-3, pp 16-13/14, 17-8
					Eng Strt, no APU, Ing <52%- 55%	>5 amps to all above except APU Bypass valve	
					All other condi- tions	>5 amps to caution light if lit (also possible power to start valve) or to APU Bypass valve if relay K22 is on (Air Source Heat/ Start switch in APU position or jammed)	
APU Control Amplifier, Fire Detector, APU T-Handle & Fire Lights Pwr Overdraw - APU FIRE DET	Tripped Crcr Brkr (CB 11)			5 Amps	No APU Fire	>5 amps to detec- tor & amplifier from the Battery Bus	-10, pp 2-16, 47 & 48 -23-2, pp 6-48, 52 & 54 -23-3, pp 18-8/9
					APU Fire	>5 amps to all systems	
No. 2 Eng Contr'l Amplifier, Fire Detectors, Eng T-Handle & Fire Lights Power Overdraw - FIRE DET NO. 2 ENG	Tripped Crcr Brkr (CB 303)				No #2 Eng Fire	>5 amps to detec- tors & amplifier from the DC Essential Bus	
					#2 Eng Fire	>5 amps to all systems	

Table: 85 (Electrical-Cont'd)

Sheet No.: 11

PARAMETER NAME- INDICATOR LABEL	INDICATOR			PARAMETER			NOTE # (SH 20)
	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	
No. 1 Eng Con- trol Amplifier, Fire Detectors, Eng T-Handle & Fire Lights & Relay K-43 Pwr Overdraw -  FIRE DET NO. 1 ENG	Tripped Crct Brkr (CB 304)		5		No #1 Eng Fire	>5 amps to detec- tor & amplifier (& relay K43 if cau- tion/advisory lgts dimmed) from DC Essential Bus	-10, pp 2-16, 47 & 48 -23-2, pp 6-48, 52 & 54 -23-3, pp 18-8/9
Fire Extinguish- er Logic Module, Impact Relay K24 Directional Con- trol Valve & No. 1 & 2 Main & Re- serve Squib Pwr Overdraw -  FIRE EXTGH	Tripped Crct Brkrs (CB 1 & CB 253)		5	Amps	Impact Sw Acti- vated (Force ≥10 Gs)	>5 amps to all systems thru CB 1 from the Battery Utility Bus	-10, pp 2-16, 47 & 48 -23-2, pp 3-18, 20 & 21 -23-3, pp 19-13/14 & 32-16/18
Eng Prime Shut- off Valves, APU Shutoff Valve, Prime Boost Pump & Prime Boost Pump On Advisory Light Pwr Overdraw -  FUEL PRIME BOOST	Tripped Crct Brkr (CB 3)		5		Fuel Pump Sw Not Off	>5 amps to all systems except Re- lay K24 from CB 1 & thru CB 253 from the No. 2 DC Primary Bus	-10, pp 2-26, 46 & 48 -23-2, pp 3-20 & 23 -23-3, pp 21-5/6 & 32-17/18
Fuel Low Level Conditioner & Fuel Low Caution Lights Pwr Overdraw -  FUEL LOW WARN	Tripped Crct Brkr (CB 154)		5		All	>5 amps to systems from No. 1 DC Primary Bus	-10, pp 2-26, 47 & 48 -23-2, pp 3-27/28 -23-3, pp 22-5/6

Table: B5 (Electrical-Cont'd)

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	PARAMETER		NOTE # (SH 20)
	TYPE	RANGE	MARKINGS		CONDITION	CONDITION TYPE - DURATION	
APU Control Sw, ESU & APU Time Delay Relay K47 Pwr Overdraw -	Tripped Crcr Brkr (CB 7 & CB 12)				>5 amps to systems from Battery Util- ity Bus & Battery Bus respectively	-10, pp 2-46, 48 & 52 -23-2, pp 3-32 & 35 -23-3, pp 24-16/17 & 32-17/18	
APU CONTR INST							
Main Xmsn Oil Pressure & Temp Caution Lgt Pwr Overdraw -	Tripped Crcr Brkr (CB 211)				>5 amps to lights from No. 2 DC Primary Bus	-10, pp 2-36, 37, 47 & 48 -23-3, pp 26-8	
MAIN XMSN							
Intermediate & Tail Rotor Gear- box Temp Caution Lgts & all Xmsn Chip Caution Lgts Pwr Overdraw -	Tripped Crcr Brkr (CB 317)		5	All	>5 amps to lights from the AC Essential Bus	-10, pp 2-37, 47 & 48 -23-3, pp 26-8 & 27-7/8	
CHIP DET							
Ground from CB 404 pin 3 - BACKUP PUMP PWR	Tripped Crcr Brkr (CB 153)		.5		Unspecified	-10, p 2-48 -23-3, p 29-27	13
Hydraulic Logic Modules & Re- lays K19, K31 & K46 Pwr Overdraw -	Tripped Crcr Brkr (CB 324)		5		>5 amps to systems as selected by Backup Hyd Pump sw. Power is from the DC Essential Bus	-10, pp 2-35 -23-2, pp 5-2, 3, 10, 11 & 16 -23-3, pp 29-27/34, 30-4 & 32-16	
BACKUP HYD CONTR							

Table: 85 (Electrical-Cont'd)

Sheet No.: 13

PARAMETER NAME- INDICATOR LABEL	TYPE	INDICATOR			OPERATING MODE	PARAMETER		REFERENCES (TM 55-1520-237)	NOTE # (SH 20)
		RANGE	MARKINGS	UNITS		CONDITION	CONDITION TYPE - DURATION		
2nd Stage Pri- mary Servo Shut- off Valve & Logic Module Pwr Overdraw - NO. 2 SERVO CONTR	Tripped Crc't Brkr (CB 228)							-10, p 2-35 -23-2, pp 5-2, 3, 10, 11 & 16 -23-3, pp 29-27/34, 30-4 & 32-16	
#1 Pri Servo Press & #2 Hyd Pump Caution Lgts & Logic Module Pwr Overdraw - NO. 2 SERVO WARN	Tripped Crc't Brkr (CB 227)					>5 amps to systems from No. 2 DC Primary Bus			
1st Stage Pri- mary Servo Shut- off Valve, Tail Rotor Servo Sw Position Sense to Logic Module Pwr Overdraw - NO. 1 SERVO CONTR	Tripped Crc't Brkr (CB 128)		5	Amps	All	>5 amps to systems from No. 1 DC Primary Bus			
#2 Pri Servo Press & #1 Hyd Pump Caution Lgts & Logic Module Pwr Overdraw - NO. 1 SERVO WARN	Tripped Crc't Brkr (CB 127)								
Tail Rotor Quad- rant Caut'n Lgt, #2 Tail Rotor Servo On Ad- visory Lgt & Logic Module Pwr Overdraw - T RTR SERVO WARN	Tripped Crc't Brkr (CB 129)								

Table: 85 (Electrical)-Cont'd

Sheet No.: 14

PARAMETER NAME- INDICATOR LABEL	INDICATOR		OPERATING MODE	CONDITION	PARAMETER		NOTE # (SH 20)
	TYPE	RANGE			CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-237)	
Ext Pwr Con- nected Advisory Lgt & DC Ess Bus Off Caution Lgt Pwr Overdraw - BATT & ESNTL DC WARN EXT PWR CONTR	Tripped Crcd Brkr (CB 4)			>5 amps to one or both lights from the Battery Bus		-10, pp 2-46/51 -23-2, pp 6-6/18 -23-3, pp 31-18/22 & 32-13/18	
AC Essential Bus Off, #1 & #2 Conv Caution Lgts Pwr Overdraw - ESNTL BUS AC & CONV WARN	Tripped Crcd Brkr (CB 5)		A11	>5 amps to light from Battery Bus			
#1 (2) Gen Cau- tion Lgts Pwr Overdraw - NO. 1 (2) GEN WARN	Tripped Crcd Brkrs (CB 130 & CB 230)			>5 amps to light from #1 (2) DC Primary Busses respectively			
AC Essential Bus Pwr Overdraw - AC ESNTL BUS SPLY	Tripped Crcd Brkrs (CB 125 & CB 257)		#2 AC Pri Bus Off	>7.5 amps to AC Essential Bus and to AC ESNTL BUS XFR relay (K8) from the #1 AC Primary Bus			
T12 Auto Trans- former Pwr Overdraw - AUTO XFMR	Tripped Crcd Brkr (CB 224)		#1 AC Pri Bus Off	>7.5 amps to AC Essential Bus from #2 AC Primary Bus			
			A11	>5 amps to trans- former from AC Essential Bus			

Table: 85 (Electrical-Cont'd)

PARAMETER NAME- INDICATOR LABEL	TYPE	INDICATOR			OPERATING MODE	PARAMETER		REFERENCES (TM 55-1520-237)	NOTE # (SH 20)
		RANGE	MARKINGS	UNITS		CONDITION	CONDITION TYPE - DURATION		
DC Bus Tie Cntrl Relay (K15) Pwr Overdraw - BUS TIE CNTRL	Tripped Crcd Brkrs (CB 131 & CB 231)		5	Amps	#1 Con- verter Failure	>5 amps to relay from #2 DC Primary Bus		-10, pp 2-46/51 -23-2, pp 6-6/18 -23-3, pp 31-18/22 & 32-13/18	
Utility Receptacle Pwr Overdraw - UTIL RECP	Tripped Crcd Brkr (CB 260)		7.5		#2 Con- verter Failure	>5 amps to relay from #1 DC Primary Bus			
Battery Charger Current Over- draw - BATT CHR	Tripped Crcd Brkrs (CB 232 & CB 258)		7.5 & 5 (Respec- tively)		All	>7.5 amps to re- ceptacle from the #2 AC Primary Bus			
DC Essential Bus Pwr Overdraw - DC ESNTL BUS SPLY	Tripped Crcd Brkrs (CB 102 & CB 202)		50		All	>7.5 amps thru CB 232 from the #2 DC Primary Bus or >5 amps booster current thru CB 258 from the #2 AC Primary Bus			
ESNTL DC BUS SPLY	Tripped Crcd Brkr (CB 6)				#1 & #2 Con- verter failed, Battery > 35% ± 5% charge	>50 amps from the No. 1 or No. 2 DC Primary Busses respectively. (Note CB 102 also powers No. 2 DC ESNTL BUS SPLY Relay K10)			
28 vdc Utility Receptacle Pwr Overdraw - UTIL RECP CABIN	Tripped Crcd Brkr (CB 156)		7.5		All	>7.5 amps to receptacle from No. 1 DC Primary Bus			

Table: B5 (Electrical)-Cont'd)

Sheet No.: 16

PARAMETER NAME- INDICATOR LABEL	INDICATOR			PARAMETER			NOTE # (SH 20)
	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	
Battery Bus Pwr Overdraw - BATT BUS SPLY	Tripped Crc't Brkr (CB 301)		10		All	>10 amps to Bus from DC Essential Bus	-10, pp 2-46/51 -23-2, pp 6-6/18 -23-3, pp 31-18/22 & 32-13/18
DC ESNTL Bus Fail Relay Pwr Overdraw - ESNTL DC SENSE	Tripped Crc't Brkr (CB 302)		5		All	>5 amps to relay from DC Essential Bus	
Battery Analyzer/Condi- tioner Relay (K2), Battery Relay (K7) & No. 2 DC Esntl Bus Sply Relay (K9) Pwr Overdraw - BATT BUS CONTR	Tripped Crc't Brkr (CB 2)		5		Battery > 35% $\pm$ 5% chrg (Batt SW on)	>5 amps to relays from Battery Utility Bus	
Non Flgt Panel Lights Pwr Overdraw - LIGHTS NON FLT	Tripped Crc't Brkr (CB 249)			Amps	Battery < 35% $\pm$ 5% chrg (Batt SW on)	>5 amps to relays except K9	-10, pp 2-54 & 46/51 -23-2, pp 6-27, 29, 30, 32, 36, 38 & 40 -23-3, pp 33-6 & 36-5
Pilot's Flt Instrument & PDU Lgts Pwr Overdraw - LIGHTS PLT FLT	Tripped Crc't Brkr (CB 248)				All	>5 amps to lgts from No. 2 DC Primary Bus	
Copilot's Flt Instrument & CPDU Lgts Pwr Overdraw - LIGHTS CPLT FLT	Tripped Crc't Brkr (CB 150)					>5 amps to lgts from No. 1 AC Primary Bus	

Table: B5 (Electrical-Cont'd)

Sheet No.: 17

PARAMETER NAME - INDICATOR LABEL	INDICATOR			PARAMETER			REFERENCES (TM 55-1520-237)	NOTE # (SH 20)
	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION		
Pilot's Standby Compass, Sec- ondary & Flood Light Pwr Overdraw -	Tripped Crcct Brkr (CB 310)					>5 amps to lamps selected by ap- plicable sw's, from DC Essential Bus	-10, pp 2-54 & 46/51 -23-2, pp 6-27, 29, 30, 32, 36, 38 & 40 -23-3, pp 33-6 & 36-5	
LIGHTS SEC PNL								
White Flood Lgts Pwr Overdraw -	Tripped Crcct Brkr (CB 250)					>5 amps to lgts from No. 2 AC Primary Bus		
LIGHTS CKPT FLOOD								
Red Secondary Lgts Pwr Overdraw -	Tripped Crcct Brkr (CB 149)					>5 amps to lgts from No. 1 AC Primary Bus		
LIGHTS SEC								
Upper Console Lgts Pwr Overdraw -	Tripped Crcct Brkr (CB 148)				All	>5 amps to lgts from No. 1 AC Primary Bus		
LIGHTS UPPER CSL								
Lower Console Lgts, Dimming Control & Relay K41 Pwr Overdraw -	Tripped Crcct Brkr (CB 141)					>5 amps to lgts from No. 1 DC Primary Bus		
LIGHTS LMR CSL								
Cabin Dome Lgts Pwr Overdraw -	Tripped Crcct Brkr (CB 147)					>5 amps to lgts from No. 1 AC Primary Bus		
LIGHTS CABIN DOME								
Cockpit Utility Lgts Pwr Overdraw -	Tripped Crcct Brkr (CB 8)					>5 amps to lgts from Battery Utility Bus		
UTIL LTS CKPT								



Table: B5 (Electrical-Cont'd)

Sheet No.: 18

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	PARAMETER			NOTE # (SH 20)
	TYPE	RANGE	MARKINGS		UNITS	CONDITION	CONDITION TYPE - DURATION	
Formation Lgts Dimming Control & Formation Lgts Pwr Overdraw - LIGHTS FORM HV	Tripped Crcd Brkr (CB 246)					>5 amps to system from No. 2 AC Primary Bus		-10, pp 2-55, 47, 48 & 51 -23-2, pp 6-41, 43/47 -23-3, pp 39-4
Formation Lgts Pwr Overdraw - LIGHTS FORM LV	Tripped Crcd Brkr (CB 245)					>5 amps to lights from dimmer control		
Position Lgts & Dimmer & Flasher Crcd Pwr Overdraw - POS LTS	Tripped Crcd Brkr (CB 212)		5			>5 amps to system from No. 2 DC Primary Bus		
Landing Light Motor, Control & Advisory Lgt Pwr Overdraw - LIGHTS RET LDG CONT	Tripped Crcd Brkr (CB 138)			All	Amps	>5 amps to system from No. 1 DC Primary Bus		
Landing Lgt Lamp Pwr Overdraw - LIGHTS RET LDG PMR	Tripped Crcd Brkr (CB 137)		25			>25 amps to lamp from No. 1 DC Primary Bus		
Anti-Collision Lgts Pwr Supply Current Over- draw - LIGHTS ANTI-COLL	Tripped Crcd Brkr (CB 247)		5			>5 amps to system from No. 2 AC Primary Bus		

Table: B5 (Electrical)-Cont'd

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	PARAMETER		NOTE # (SH 20)
	TYPE	RANGE	MARKINGS		CONDITION	CONDITION TYPE - DURATION	
Search Light Motor Pwr Overdraw - LIGHTS SCHLT CONT	Tripped Crcr Brkr (CB 308)		5		>5 amps to motor from DC Essential Bus		-10, pp 2-55, 47, 48 & 51 -23-2, pp 6-41, 43/47 -23-3, pp 39-4
Search Lgt Lamp Pwr Overdraw - LIGHTS CONTR PWR	Tripped Crcr Brkr (CB 309)		20		>20 amps to lamp from DC Essential Bus		
Tail Wheel Lock Actuator & Lgts Pwr Overdraw - TAIL WHEEL LOCK	Tripped Crcr Brkr (CB 311)		5	All	>5 amps to system from DC Essential Bus		-10, pp 2-11, 47 & 48 -23-3, p 7-4
Master Warning Pnl, Caution/ Advisory Pnl & Audible Warning Unit Pwr Overdraw - CAUT/ADVSY PNL	Tripped Crcr Brkr (CB 325)		5		>5 amps to system from DC Essential Bus		-10, pp 2-47, 48 & 57 -23-2, pp 6-70, 72 & 73 -23-3, pp 47-8/10
Caution/Advisory Pnl Lamp Test Pwr Overdraw - LIGHTS CAUT ADVSY	Tripped Crcr Brkr (CB 139)		7.5		>7.5 amps to lamps from No. 1 DC Primary Bus		

Table 95: (Electrical-Cont'd)

Sheet No.: 20

NOTES:

1. Sensors are contained in the respective generator control units (GCU's). When any of the voltage, current or frequency limits are exceeded, the GCU's cause the No. 1 or No. 2 generator control relays (K1 & K2) to close, and power is supplied to the caution lights from the No. 1 and No. 2 DC Primary Busses, respectively, through caution/advisory panel channel card A1. Additionally, the caution light may be activated by placing the applicable generator switch in the TEST position, which will activate the test relay in the appropriate GCU.
2. Sensors similar to those above, except GENERATORS APU switch must also be enabled to light the capsule. Power is supplied to the switch from the PWR READY terminal of the APU GCU, and is routed through APU/EXT PWR CNTOR relay (K3) and the AC BUS TIE CNTOR Relay (K4) to caution/advisory panel channel card A3.
3. Sensor is a lead contact in the main bearing which is exposed when the bearing wears down and grounds the caution lamp, via caution/advisory panel channel card A3. Power to the lights is most likely from the No. 1 and No. 2 DC Primary Busses, through the No. 1 and No. 2 GEN WARN circuit breakers, since they supply power to channel card A3.
4. Sensor is the AC ESNTL BUS FAIL Relay (K13), which receives its power from the AC Essential Bus. Light circuitry is via caution/advisory panel channel card A1, with power from the Battery Bus.
5. Sensor is the external power plug which, when inserted in the external/power receptacle (J136) jumpers pins N & E of the receptacle, thereby grounding pin J118-M of caution/advisory panel channel card A3. Power is most likely supplied by the DC Essential Bus through the CAUT/ADVSY PNL circuit breaker (CB 325).
6. Sensors are the No. 1 (2) DC PRI BUS CNTOR relays, located in the No. 1 (2) Junction Boxes. The relays are energized by the respective converter output. Power to the caution lights comes from the Battery Bus through the ESNTL BUS AC & CONV WARN circuit breaker, and is routed through the applicable relay to caution/advisory panel channel card A1.
7. Sensor is the DC ESNTL BUS FAIL RELAY (K20) which is energized when power is on the DC Essential Bus. Power to the caution capsule, on channel card A1, comes from the Battery Bus through the BATT & ESNTL DC WARN EXT PWR CNTOR circuit breaker. The bus disconnect normally occurs when the No. 1 and No. 2 DC Primary Busses both lose power and the battery is below 35%  $\pm 5\%$  charge. Additional relays which control the connection of the DC Essential Bus to a power source are the No. 1 and No. 2 DC ESNTL BUS SPLY relays (K10 & K9), the low battery charge disconnect relay (K1) in the Battery Analyzer/Conditioner and the auxiliary contacts of the No. 1 and No. 2 DC PRI BUS CNTOR relays (K16 & K6).
8. Sensor is the BATTERY ANALYZER/CONDITIONER. The operator's manual says the turn-on threshold is 40%  $\pm 5\%$ , but all other references just use 40%. Signal routing is to caution/advisory panel channel card A1.
9. Same sensor as above. Signal goes to caution/advisory panel channel card A2. In both this case and the one above, the light power source is not specified, but is most likely the BATTERY ANALYZER/CONDITIONER.
10. CB 404 is on the No. 1 Main Electrical Junction Box.
11. Unable to identify circuit breaker number since information on the Range Extension Kit (No. 50) is not yet available on TM 55-1520-277-23-3.
12. If the APU Generator is the only source of AC power and the Hydraulic Backup Pump is operating, power is applied from the Battery Bus through CB 10, through the contacts of the energized APU/EXT PWR CNTOR relay (K3), the contacts of the de-energized No. 2 GEN CNTOR relay (K2), the contacts of the de-energized No. 1 GEN CNTOR relay (K1), and the contacts of the energized HYD PWR PUMP relay (K19) to energize relay K21 which disconnects heater element power to the Anti-Ice Controller.
13. Insufficient information to determine function of this circuit breaker.

# SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: UH-60A

Table: 86

SUBSYSTEM: Miscellaneous

Sheet No.: 1

PARAMETER NAME - INDICATOR LABEL	TYPE	INDICATOR			OPERATING MODE	CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-237)	NOTE # (SH 3)
		RANGE	MARKINGS	UNITS					
Stabilator Position Error Signal -  STABILATOR	Beeping Tone in ICS		--			>10° pos. error for 0-30KTS, down to >4° pos. error for >150KTS	Cautionary - unspecified	-10, pp 2-33/34 & 61 -23-2, p 6-75 -23-3, p 58-5 (TM 11-1520-237) -23-1, p 2-18	1
	Caution Lgt		Amber		Auto- matic				
Pitch Bias Actuator (PBA) Position Error Signal -  PITCH BIAS FAIL	Caution Lgt		Amber	--	All	Signal strength indicates PBA is no longer respond- ing to drive signals	Cautionary - unspecified	-10, pp 2-31 & 61 -23-2, p 6-76 -23-3, p 58-8 (TM 11-1520-237) -23-1, pp 2-6, 9 & 12	2
SAS Actuator Servo Valve Hydraulic Pressure -  SAS OFF	Caution Lgt		Amber	psi	All	<2000 ±50 to the servo valves on the pitch/trim, roll and yaw SAS actuators	Cautionary - unspecified	-10, pp 2-32 & 61 -23-2, pp 5-3 & 6-76 -23-3, p 58-8 (TM 11-1520-237) -23-1, pp 2-3 & 5 -23-2, pp 2-94 & 101	3
Pitch Trim Servo and/or Roll or Yaw Trim Actu- ator Pos Error -  TRIM FAIL	Caution Lgts (2)		Amber	psi	All	A trim channel has been disengaged.	Cautionary - unspecified	-10, pp 2-32, 33, 61 & 62 -23-2, p 6-76 (TM 11-1520-237) -23-1, pp 2-9, 10 & 14	4
FLT PATH STAB						The flight path stabilization sec- tion of the compu- ter is disabled.			
Left (Right) Pitot Heat Ele- ment Current -  LFT (RT) PITOT HEAT	Caution Lgts (2)		Amber	--	Pitot Heat Sw On	Low current in elements	Cautionary - unspecified	-10, pp 2-40, 60 & 62 -23-2, pp 6-56, 60, 62, 75 & 77	5

Table: B6 (Miscellaneous - Cont'd)

Sheet No.: 2

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	PARAMETER		REFERENCES (TM 55-1520-237)	NOTE # (SH 3)
	TYPE	RANGE	MARKINGS		CONDITION	CONDITION TYPE - DURATION		
Rotor Blade De-Ice Heating Element Integrity -	Caution Lgt		Amber	All	Short or open cir- cuit in main rotor element	Cautionary - unspecified	-10, pp 2-40/42, 60/62 -23-2, pp 6-75/76	6
MR DE-ICE FAIL					Short or open cir- cuit in tail rotor element			
TR DE-ICE FAIL								
Blade De-Ice System Status -	Caution Lgt		Amber	All	Partial system failure. Possible uneven ice shed- ding	Cautionary - unspecified		
MR DE-ICE FAULT								
No. 2 Engine Inlet Ice Probe Vibration Frequency -	Caution Lgt		Amber	All	Frequency shift due to ice form- ing on probe	Cautionary - unspecified		
ICE DETECTED							-10, pp 4-11/14 & 2-63 -23-2, pp 2-18/21 & 6-77 -23-3, pp 2-9/10 & 58-9	7
Cargo Hook Release Switch Power Enable -	Advisory Lgt		Green	All	Release switches enabled	Advisory - unspecified		
HOOK ARMED							-10, pp 2-11 & 63 -23-2, pp 2-25/27 & 6-77 -23-3, pp 6-5 & 58-9	8
Cargo Hook Load Beam Position -	Advisory Lgt		Green	All	Load beam open	Advisory - unspecified		
CARGO HOOK OPEN							-10, pp 2-11 & 63 -23-2, pp 2-25/27 & 6-77 -23-3, pp 6-5 & 58-9	9
Parking Brake Lever Position -	Advisory Lgt		Green	All	Handle is in up position	Advisory - unspecified		
PARKING BRAKE ON							-10, pp 2-55 & 63 -23-2, pp 6-41, 43, 46 & 77 -23-3, pp 42-5/6 & 58-9	10
Landing Light Lamp Power -	Advisory Lgt		Green	All	Power is on	Advisory - unspecified		
LDS LT ON								

## NOTES:

1. Sensors are feedback potentiometers in each actuator. These signals are applied to the No. 1 or No. 2 stabilator amplifiers, as applicable, which generate error signals for position commanded versus position sensed. These error signals are applied to a fault circuit which trips according to the values shown under the Parameter Condition column. The values shown seem to represent the lower and upper bounds of an error versus airspeed fault indication threshold, but this is not specifically described in any reference. The fault signal is applied to the Stabilator Control/AFCs panel, which in turn produces a signal that is applied to caution/advisory panel channel card A3 and to relay K44 of the left relay panel. This relay energizes the beeping tone of Audible Warning Unit (which has priority over the steady tone signal) and applies it to the ICS through a junction box assembly, while also energizing the warning reset circuit.
2. Sensor is contained in PBA and is most likely a potentiometer driven by PBA position. The drive signal to light the capsule is generated by the Stability Augmentation System/Flight Path Stabilization computer and is routed to caution/advisory panel channel card A2.
3. Sensor is a pressure switch on the pilot assist manifold. The signal is routed from the DC Essential Bus, via the SAS BOOST circuit breaker and pressure switch, to caution/advisory panel channel card A2.
4. The lamp drive signals are produced separately by the TRIM and FPS sections of the computer. Sensors for the trim section are position feed back sensors which are most likely mechanically linked potentiometers. Sensors for the FPS section are actuator return signal (current sensors which are routed to the Fault Monitor section of the computer) which will produce an FPS disable signal causing the FPS to idle and light the FLT PATH STAB caution capsule. Hence the two capsules could be lit independently if feedback information from the two sets of signals did not agree on a threshold error value for the TRIM and FPS sections. Power to the capsules is through channel cards A2 and A1 respectively.
5. Sensors are current switches. Power to the lights is routed through the closed left (right) hand switch from the No. 1 DC Primary Bus, via the No. 1 Eng Anti-Ice circuit breaker, to caution/advisory panel channel cards A1 and A2.
6. Need more information on blade de-ice kit. (Listed as "to be provided" in TM 55-1520-237-2 & 3.) Operating modes may be tied in with de-ice system operation.
7. Sensor is the cargo hook release arming switch. When placed in the ON position, power is supplied from the No. 2 DC Primary Bus, through the CARGO HOOK CONT circuit breaker, to caution/advisory panel channel card A3.
8. Sensing is accomplished using the Hook Open Switch (S2) or the Linkage Safe Switch (S3). Signal routing is the same as for note 7 above.
9. Sensor seems to be a position microswitch versus a pressure switch. Power is routed from the No. 1 DC Primary Bus through the LIGHTS ADVSY circuit breaker, through the switch (S42) over to channel/advisory panel channel card A3.
10. Power is routed to caution/advisory panel channel card A3 from the No. 1 DC Primary Bus, through the LIGHTS RETR LDG CONT circuit breaker, through contacts of an unspecified relay in the RH Relay Panel. The relay is actuated by the landing light lamp ON/OFF switch, closing relay K28, the contacts of which energize the referenced relay that turns on the advisory light. There is a maximum landing light extension airspeed of 180Kts.

SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: UH-60A

SUBSYSTEM: Auxiliary Power Unit (APU)

Table: B7

Sheet No.: 1

PARAMETER NAME - INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		NOTE # (SH 2)
	TYPE	RANGE	MARKINGS			CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-237)	
APU Start Sequence (Ng, Spool-Up Time, Oil Press. & EGT) -	Advisory Lgt		Green	All	1.5 seconds after Ng reaches 90% and Ng > 90%	Advisory - unspecified	-10, pp 2-52 & 63 -23-2, pp 3-32 & 6-77 -23-3, pp 24-7, 16 & 58-7	1
APU ON								
APU FAIL	Caution Lgt		Amber	All	Any of the follow- ing items: 1. Ng reaches 90% but then goes below 90%. 2. Ng > 110% 3. 5% < Ng < 90% for over 40 seconds 4. EGT < 250°F @ 30% Ng 5. Ng > 70% and oil press. < (6 ± 1) psi. 6. EGT > 660°C		-10, pp 2-52 & 62 -23-2, pp 3-32 & 6-76 -23-3, pp 24-7, 16 & 58-7	2
APU Oil Temperature - APU OIL TEMP HI	Caution Lgt		Amber	All	> 300°F @ Ng ≥ 70%	Cautionary - unspecified	-10, pp 2-52 & 62 -23-2, pp 3-32 & 6-76 -23-3, pp 24-16 & 58-7	3
APU Accumulator Pressure - APU ACCUM LOW	Advisory Lgt		Green	All	< 2600	Advisory - unspecified	-10, pp 2-53 & 63 -23-2, pp 5-2, 10, 13 & 6-77 -23-3, pp 29-29 & 58-7	4

## NOTES:

1. Sensors include a magnetic pickup (Mg), pressure switch (S2) and alumel-chromel thermocouple in the APU. These sensors output signals to the electronic sequence unit (ESU) which supplies a timer and combinational logic to control the APU hydraulic start valve, fuel shutoff valve, main fuel valve, start fuel valve, maximum fuel valve, ignition exciter, start bypass valve, bite indicator and the APU caution/advisory lights. The start bypass valve is enabled and the maximum fuel valve is turned on under the same conditions which turn on the APU ON light. Power is routed by the ESU to caution/advisory panel channel A2.
2. Same sensors as above. Light indicates a start sequence failure, where the specific failure (items 1-6 in the Parameter Condition column) may be checked on the Built In Test Equipment (BITE) indicator.
3. Sensor is a thermal switch in the oil sump. The second and third page references indicate a trip condition occurs above 300°F while the fourth reference says "about 301°F". No tolerance is given in any reference. The ESU provides 28 vdc to the thermal switch when Mg  $\geq$  70%. The ESU senses switch position and supplies 28 vdc to caution/advisory panel channel A2 at the temperature threshold.
4. Sensor is a pressure switch which monitors nitrogen gas pressure used to squeeze hydraulic fluid from the accumulator to the APU start motor. The second reference gives the threshold as 2600 psi while the sixth reference (p. 6-77, TM 55-1520-237-23-2) says it is 2800 psi. However, p. 5-13 shows a normal charge of 2850  $\pm$ 150 psi accumulator hydraulic pressure. Hence, the 2600 psi seems the most likely threshold. The pressure switch routes 28 vdc from the DC Essential Bus, through the BACKUP HYD CONTR (CB324) circuit breaker, to caution/advisory panel channel A2.



SUBSYSTEM PARAMETER DATA LIST  
FOR THE  
OH-58C

# SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: OH-58C

SUBSYSTEM: Engine (T63-A-720)

Table: C1

Sheet No.: 1

PARAMETER NAME - INDICATOR LABEL	TYPE	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		REFERENCES (TM 55-1520-235)	NOTE # (SH 4)
		RANGE	MARKINGS	UNITS			CONDITION TYPE	DURATION		
Engine Gas Producer (N <sub>1</sub> ) Speed - RPM	Circular Dial	0-110	(62-105)G (105)R	%	Engine Start	12 @ OAT <-18°C	Minimum (to open throttle to engine idle) -25 sec (ext pwr) or 40 sec (battery pwr)	-10, pp 2-17, 5-4/6 & (TM 55-1520-228) -23-1, pp 8-5, 9/10, 9-44/45 & 48 -23-2, pp F-18, 27, 52 & 65	1	
						13 @ -18°C <OAT <7°C				
						15 @ OAT > 7°C				
					Throttle at idle, engine started	30 @ NR = 0	Maximum - none allowed			
					Throttle above idle - engine running	60-62	Normal - continuous			
ENGINE OUT	Warning Light	--	--	--	All	62-105	Normal - continuous		2	
						105	Maximum - continuous			
						106	Maximum - 15 seconds			
					Collective not full down	≤(55±3)	Warning (possible flame out) - continuous			
Engine Power Turbine (N <sub>2</sub> ) Speed - ENGINE RPM	Circular Dial (part of dual tachometer)	0-120	(98-100)G (100)R	%	Throttle full open (engine running)	98-100	Normal - continuous	-10, pp 2-17 & 5-2 (TM 55-1520-228) -23-1, pp 8-5/8 -23-2, pp F-18 & 52	3	
						100	Maximum - continuous			
						101	Maximum (full beep) - (transient)			
						102	Maximum - 15 seconds			

Table: C1 (Engine - Cont'd)

PARAMETER NAME - INDICATOR LABEL	INDICATOR				OPERATING MODE	PARAMETER		REFERENCES (TM 55-1520-228)	NOTE # (10-4)
	TYPE	RANGE	MARKINGS	UNITS		CONDITION	CONDITION TYPE - DURATION		
Turbine Outlet Temperature - TOT	Circular Dial	100-1000	(300-738)G (738-810)Y (810)R (927)R	°C	Engine starting throttle closed	0-150	Normal - continuous	-10, pp 2-17, 5-3, 8-9, 14 & 9-10 (TM 55-1520-228) -23-1, pp 8-14/18 -23-2, pp F-20 & 54	4
					Engine starting throttle at idle	150	Maximum (to open throttle to idle) - continuous		
						0-738	Normal - continuous		
						738-810	Cautionary - transient		
						810-927	Cautionary - 10 seconds		
					Engine running	927	Maximum - 1 second		
						300	Maximum - continuous		
						300-738	Normal - continuous		
						738-810	Cautionary - 30 minutes		
					Engine shut- down	810	Maximum - 30 minutes		
400	Maximum (w/o motoring) - none allowed								
Engine Torque - TORQUE	Circular Dial	0-120	(0-85)G (85-100)Y (100)R	%	200	Maximum (during motor- ing) - none specified	-10, pp 2-17 & 5-3 (TM 55-1520-228) -23-1, pp 8-4/4A	5	
					0-85	Normal - continuous			
					85-100	Cautionary - 5 minutes			
					100	Maximum - 5 minutes			
Engine Oil Pressure - ENG OIL P	Shared Circular Dial	0-150	(50)G (50-110)Y (110-130)G (130)R	psi	50	Minimum - transient	-10, pp 2-17 & 5-3 (TM 55-1520-228) -23-1, pp 803 & 12/14 -23-2, pp F-20 & 54	6	
					50-110	Cautionary - transient			
					110-130	Normal - continuous			
					130	Maximum - continuous			
Engine Oil Temperature - ENG OIL T	Shared Circular Dial	-50 - 150	(60-107)G (107)R	°C	-50	Minimum (cold weather) - unspecified		7	
					60-107	Normal - continuous			
					107	Maximum - continuous			

Table: C1 (Engine - Cont'd)

PARAMETER NAME - INDICATOR LABEL	TYPE	INDICATOR			OPERATING MODE	CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-235)	NOTE # (SH 4)
		RANGE	MARKINGS	UNITS					
Engine Oil Reservoir Level - ENG OIL BYPASS	Caution Light	--	Amber	Gallons	Engine oil bypass switch OFF	<1.1	Cautionary - none specified	-10, pp 2-17 & 29 (TM 55-1520-228) -23-1, pp 4-32, 9-42/43 & 46 -23-2, pp F-27 & 65	8
					Engine oil bypass switch AUTO		Cautionary - none speci- fied but monitor engine oil temp. (see note)		
Engine Geartrain Integrity - ENG CHIP DET	Caution Light	--	Amber	--	All	Sensor contacts grounded by par- ticles from engine gearing	Cautionary - none specified	-10, pp 2-17 & 29 (TM 55-1520-228) -23-1, pp 4-26, 9-43 & 46/47 -23-2, pp F-27 & 65	9
Engine Automatic Religion System Operation - ENGINE RELIGHT	Advisory Light	--	--	--	Engine relight switch ON	Engine flamed out and ignition being automatically applied	Advisory - none specified	-10, p 2-16 (TM 55-1520-228) -23-1, pp 9-53 & 54 -23-2, pp F-41 & 70	10

Table: C1 (Engine - Cont'd)

NOTES:

1. Sensor is a tachometer generator, powered by 28 VDC. Method of operation is not described.
2. Description of sensor operation was not in the available literature. An rpm sensor (S18) somehow discriminates the Nj rpm threshold and supplies a signal to the Audio Warning Engine Out Signal device DS17 and to the ENG OUT warning light DS14. The light flashes for 30 seconds and then illuminates steadily. The audio warning is disabled when the collective is full down by a switch (S70). The type of tone is not described, nor is the color of the warning light.
3. Sensor is similar to that described in Note 1 above.
4. Sensors are 4 alumel-chrome thermocouples. The "A" model system requires no external power while the "C" model does.
5. Indicator is wetline type, driven by an oil pressure line ("gage line") from the engine plenum.
6. Indicator is a wetline type as above. Tolerance at 130 psi is  $\pm 4.5$  psi.
7. Sensor is a variable resistance bulb type, with resistance values of 83.77 ohms ( $-20^{\circ}\text{C}$ ) to 104.6 ohms ( $+40^{\circ}\text{C}$ )  $\pm 0.4$  ohms for test points.
8. Sensor is a float switch in the oil reservoir. The light is illuminated by providing a grounding path through the switch to P64D on the caution panel. When this light comes on the oil cooler bypass valve circuit is enabled. Bypass occurs when the Engine Oil Bypass Switch is in the AUTO position. According to the Operator's Manual, the high oil temperatures resulting from cooler bypass can cause an engine failure "in a few minutes." Use of this bypass feature assumes oil loss in the cooler system.
9. Sensors are magnetic plugs with contacts which provide a path to ground when bridged by ferrous metal particles. The ground is applied to P64E on the caution panel.
10. Sensor is a Reignition Control Assembly (Z11) which operates when a loss of bleed air from the compressor is sensed. The system activates approximately 5 seconds after detecting the pressure loss and remains active for about 3 seconds. The light will remain illuminated after that 3 second period however, until manually reset.

# SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: OH-58C

SUBSYSTEM: Fuel

Table: C2

Sheet No.: 1

PARAMETER NAME- INDICATOR LABEL	TYPE	INDICATOR		UNITS	OPERATING MODE	CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-235)	NOTE # (SH 2)
		RANGE	MARKINGS						
Fuel Quantity, Main Tank -	Circular Dial	0-600	(0-65)Y			0-65	Cautionary - none specified	-10, pp 2-17/19, 29, 32, 54 & 6-6 (TM 55-1520-228)	1
FUEL QTY					All	65-600	Normal - continuous	-23-1, pp 8-32/39	
20 MIN FUEL	Caution Light	--	Amber	lbs		$\leq (81.25 \pm 16.25)$	Cautionary - none specified	-23-2, pp 10-19/20, 23/24, F-37, 53 & 69	2
Fuel Boost Pump Pressure -					Fuel boost pump SW ON or Start Button ON				3
FUEL BOOST	Caution Light	--	Amber	psi		$\leq (4.5 \pm 0.5)$	Cautionary - none specified	-10, pp 2-19 & 29 (TM 55-1520-228)	
Fuel Filter Differential Pressure -					All			-23-1, pp 9-46A/47	4
FUEL FILTER	Caution Light	--	Amber	--		Fuel filter obstructed	Cautionary - none specified	-23-2, pp F-27 & 65	

Table: C2 (Fuel - Cont'd)

NOTES:

1. Total fuel capacity in the main tank is 71.5 gallons with 70.3 gallons useable. For JP-4 @ 6.5 lbs/gallon, that translates to 464.75 lbs total and 456.95 lbs useable. Note that the fuel loading chart in the Operator's Manual indicates maximum fuel is 70.3 gallons. These figures are for a crash worthy fuel system. For a non crash worthy system, total capacity is 73 gallons (see TM 55-1520-228-10 p 2-10.1). Sensors are two capacitance type probes mounted in the main tank, driven by an ac signal. The indicator receives a rectified dc signal from the upper tank unit assembly (25) proportional to the pounds of fuel in the tank. An auxiliary tank with a 23.9 gallon capacity may be added to the system. There is no fuel quantity probe in the tank so a correction card (p 2-18 of the Operator's Manual) is used.
2. Sensor is a float switch near the lower fuel quantity probe. It provides a path to ground for connector P64B on the caution panel. The threshold range used was given on page 10-20 of the last reference cited, and was actually given as 12.5  $\pm$  2.5 gallons. This translates to the range listed on sheet 1, using 6.5 lbs/gallon. The lower limit of the range is 65 lbs, which coincides with the figure given in the Operator's Manual.
3. Sensor is a pressure switch located upstream of the boost pump on top of the tank. The light turn-off threshold is 8 psi (increasing pressure). The turn-on threshold is the one listed on sheet 1. The boost pump is required for operations above a 10,000' pressure altitude.
4. The light may be on for as much as ten seconds when the boost pump is turned on. No pressure threshold for switch activation could be found in the literature.

# SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: OH-58C

SUBSYSTEM: Powertrain

Table: C3

Sheet No.: 1

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-235)	NOTE # (SH 2)
	TYPE	RANGE	MARKINGS					
Main Rotor RPM -					49-58	Cautionary - transient		
ROTOR RPM	Circular Dial (part of dual tachometer)	0-120	(49-58)Y (93R (93-110)G (110)R	All	93	Minimum - continuous	-10, pp 2-17, 21/22 & 5-2 (TM 55-1520-228) -23-1, pp 8-5/7, 10, & 9-45 -23-2, pp F-18 & 52	1
			93-110		Normal - continuous			
			110		Maximum - continuous			
ROTOR RPM	Warning Light	--	--	Collec- tive not full down	$\leq(95 \pm 1.4)$	Cautionary - none specified		2
		--	--					
Transmission Oil Pressure - XMSN OIL	Circular Dial	0-100	(30R (30-60)G (70)R	All	30	Minimum - continuous	-10, pp 2-21, 5-2 & 9-44/45 & 47 (TM 55-1520-228) -23-1, pp 6-80, -23-2, pp F-27, 63 & 65	3
			30-60		Normal - continuous			
			70		Maximum - none specified			
XMSN OIL PRESS	Warning Light	--	--		$\leq(30 \pm 2)$	Cautionary - none specified		4
Transmission Oil Temperature - XMSN OIL HOT	Warning Light	--	--	All	$\geq 110$	Cautionary - none specified	-10, p 2-21 (TM 55-1520-228) -23-1, pp 6-75, 9-45 & 46A	5
Transmission Mechanical Integrity -								
XMSN CHIP DET	Caution Light	--	Amber	All	Sensor contacts grounded by ferrous metal particles from the gearbox	Cautionary - none specified	-10, pp 2-21 & 29 (TM 55-1520-228) -23-1, pp 6-71, 80, 9-43 & 47 -23-2, pp F-27 & 65	6
Tail Rotor Gearbox Mechanical Integrity -								
T/R CHIP DET								



Table: C3 (Powertrain - Cont'd)

NOTES:

1. Sensor is a tachometer generator with a 28 VDC power source connected to the generator/indicator system. Mode of operation is not described in the available literature.
2. Sensor is an rpm interpreter (S91) which receives inputs from the tachometer generator. Mode of generation is not described in the available literature. The sensor threshold listed is from the Operator's Manual and is the only one listed in all of the references with values in % rpm. All other sources indicate a threshold of 335  $\pm$  5 rpm. The type of tone in the ICS (Audio Warning signal) is not described. The tone is disabled by switch S70 which is actuated by placing the collective full down. The color of the warning light is not described.
3. The parameter conditions shown are further amplified on page 9-9 of the Operator's Manual. If the XMSN OIL PRESS light comes on, three different courses of action are recommended, based on whether the oil pressure gauge is less than 20 psi, 20-30 psi or above 30 psi. The sensor operation is not described but the tolerance on the gauge at 70 psi is given as  $\pm$  2 psi.
4. Sensor is a pressure switch. Then turn-on threshold (decreasing pressure) is listed on sheet 1. The turn-off threshold (increasing pressure) is 36 psi. The color of the warning light is not described. Pages 9-44 & 45 of TM 55-1520-228-23-1 also indicate high pressure turn-on and turn-on thresholds, for helicopters prior to S/N 72-21061. These helicopters presumably do not have analog pressure indicating systems.
5. The only reference to a turn-on/turn-off threshold which could be found was in the Operator's Manual, page 2-21. The color of the warning light is also not described.
6. Sensors are the same as those described for the engine chip detection system.

# SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: OH-58C

SUBSYSTEM: Hydraulic

Table: 6+

Sheet No.: 1

PARAMETER NAME - INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		REFERENCES (TM 55-1520-235)	NOTE # (SH 2)
	TYPE	RANGE	MARKINGS			CONDITION TYPE -	DURATION		
Hydraulic Pressure - HYD PRESS	Caution Light	--	Amber	psi	All	≤300	Cautionary - unspecified	-10, pp 2-20 & 29 (TM 55-1520-228) -23-1, pp 7-9, 25, 9-44 & 48 -23-2, pp F-27 & 65	1

Table: C4 (Hydraulic - Cont'd)

NOTES:

1. Sensor is a pressure switch which provides a grounding path to connector P64M on the caution panel. The threshold of 300 psi is for switch closure on decreasing pressure. The increasing pressure, (switch open) threshold is 400 psi.

SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: OH-58C

Table: C5

SUBSYSTEM: Electrical

Sheet No.: 1

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		NOTE # (SH 7)
	TYPE	RANGE	MARKINGS			CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-235)	
DC Generator Load - AMPS DC	Circular Dial	0-150	(140)R	Amps	All	Maximum - none specified	-10, p 2-26, 29 & 5-2 (TM 55-1520-228) -23-1, pp 8-40 & 9-6/7 -23-2, pp F-21, 27, 55 & 65	
DC GENERATOR	Caution Light	--	Amber	--	Gen SW ON Gen Field circuit breaker in	Generator voltage ≤ (18 ±1.8) VDC or ≥ (32 ±1) VDC		1
115 VAC Bus Power - INST INVERTER	Caution Light	--	Amber	--	All	No AC power on Bus	-10, pp 2-26 & 29 (TM 55-1520-228) -23-1, pp 9-49 & 50 -23-2, pp F-17 & 51	2
DC Ammeter Power Overdraw - AMM	Tripped Crct Brkrs (2)	--	5		All	>5 amps through the ammeter circuit		3
Voltage Regulator Essential Bus Sensing Circuit Power Overdraw - GEN FIELD	Tripped Crct Brkr		10	Amps	All	>10 amps to crct from the 28 VDC Essential Bus		4
Voltage Regulator Generator Reset Crct and Non Essential Relay Pwr Overdraw - GEN & BUS RESET			5		Gen SW ON, Gen- erator on line Gen SW to RESET	>5 amps to the relay (K2) from the 28 VDC Essential Bus >5 amps to volt- age regulator (same power source)	-10, pp 2-10, 24/26 (TM 55-1520-228) -23-2, pp F-27 & 65	

Table: C5 (Electrical - Cont'd)

Sheet No.: 2

PARAMETER NAME - INDICATOR LABEL	INDICATOR			PARAMETER			NOTE # (SH 7)
	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	
Inverter Pwr Overdraw - INV PWR	Tripped Crc't Brkr		5	Amps	All	>5 amps to inverter from the 28 VDC Non Essential Bus	4
Inverter Fail Relay (K10) Pwr Overdraw -			.5			>0.5 amps to relay from the 115 VAC BUS	
AC FAIL RELAY							
N2 Governor Control Actuator Pwr Overdraw -			5			>5 amps to actu- ator from the 28 VDC Essential Bus	
GOV CONT	Sw Crc't Brkr Tripped to OFF		10				5
Auxiliary Pwr Receptacle Pwr Overdraw -						>10 amps to recep- tacle from the 28 VDC Essential Bus	
AUX RECP	Tripped Crc't Brkr		5		Starter button pressed		
Engine Auto Relight System (if installed) and/or Igniter Pwr Overdraw -						>5 amps to systems from the 28 VDC Essential Bus	
IGN ENG							
Starter Relay (K3), Voltage Regulator, Starter/Gen and Fuel Boost Relay (K16) Pwr Overdraw -	START ENG						
						>5 amps to relay K5 & to terminal A of the starter/ generator, via the pressed & voltage regulator, Starter Lockout & to K16 from the 28 VDC Essential Bus	

Table: C5 (Electrical - Cont'd)

Sheet No.: 3

PARAMETER NAME - INDICATOR LABEL	TYPE	INDICATOR		OPERATING MODE	CONDITION	PARAMETER CONDITION - 000	REFERENCE PP 45-1520-228, (SH 7)	NOTE # (SH 7)
		Wiring	Wiring					
Fuel Boost Pump Pwr Overdraw - FUEL PUMP				Starter button pressed or Fuel Boost Pump SW ON	>5 amps to the pump from the 28 VDC Essential Bus		-10, pp 2-10, 16, 19 & 24 (TM 55-1520-228) -23-2, pp F-41 & 69	
Engine Deice Control Pwr Overdraw - ENG DEICE					>5 amps to control from the 28 VDC Essential Bus		-10, pp 2-10, 15 & 24 (TM 55-1520-228) -23-1, p 4-22 -23-2, pp 12-1 & F-25	
Gas Producer Tachometer Sys Pwr Overdraw - GAS PROD TACH					>5 amps to the sys- tem from the 28 VDC Essential Bus		-10, pp 2-10, 17 & 24 (TM 55-1520-228) -23-2, pp F-18 & 52	
Rotor & Engine Speed Indicating Sys Pwr Overdraw - DUAL TACH	Tripped Crct Brkr			All	>5 amps to the sys- tem from the 28 VDC Essential Bus		-10, pp 2-10, 17 & 24 (TM 55-1520-228) -23-2, pp F-18 & 52	
Turbine Outlet Temp. Indicator Pwr Overdraw - TURB OUTLET TEMP					>5 amps to the in- dicator from the 28 VDC Essential Bus		-10, pp 2-10, 17 & 24 (TM 55-1520-228) -23-1, pp 8-18/18A -23-2, p F-54	
Eng Oil Temp. Sys Pwr Overdraw - ENG OIL TEMP					>5 amps to sys- tem from the 28 VDC Essential Bus		-10, pp 2-10, 17 & 24 (TM 55-1520-228) -23-2, pp F-20 & 54	
Eng Oil Bypass Relay (K4) & Valve Pwr Overdraw - ENG OIL BYPASS					>5 amps to sys- tem from the 28 VDC Essential Bus		-10, pp 2-10 & 24 (TM 55-1520-228) -23-2, pp F-27 & 65	
Fuel Indicating Sys Pwr Overdraw - FUEL QTY					>5 amps to sys- tem from the 28 VDC Essential Bus		-10, pp 2-10, 19 & 24 (TM 55-1520-228) -23-2, p F-53	

Table: C5 (Electrical - Cont'd)

Sheet No.: 4

PARAMETER NAME - INDICATOR LABEL		TYPE	RANGE	INDICATOR		PARAMETER		NOTES (Ref. 7)
				MARKINGS	UNITS	OPERATING mode	CONNECTION	
Force Trim Magnetic Brake(s) Pwr Overdraw -				5			>5 amps to brakes from the 28 VDC Essential Bus	-10, pp 2-10, 20 & 24 (TM 55-1520-228) -23-1, p 9-36 -23-2, p F-26
FORCE TRIM								
Hydraulic Bypass Solenoid Pwr Overdraw -	Tripped Crcr Brkr					All	>5 amps to solen- oid from the 28 VDC Essential Bus	-10, pp 2-10, 20 & 24 (TM 55-1520-228) -23-1, p 9-34 -23-2, p F-26
HYD BOOST SOL								
Xmsn Oil Pressure Indicating Sys Pwr Overdraw -				1			>1 amp to the sys- tem from the 28 VDC Essential Bus	-10, pp 2-10, 21 & 24 (TM 55-1520-228) -23-1, pp 8-41/43 -23-2, p F-63
XMSN OIL PRESS								
Pitot Tube Heater Pwr Overdraw -					Amps		>5 amps to heater from the 28 VDC Essential Bus	
PITOT HTR								
Heater Solenoid (L2) Pwr Overdraw -	Sw Crcr Brkr Tripped to OFF					System activated by Switch Crcr Brkr	>5 amps to solen- oid from the 28 VDC Essential Bus	-10, pp 2-10, 22 & 24 (TM 55-1520-228) -23-1, pp 9-67 & 68 -23-2, p F-25
HTR							>5 amps to blow- ers from the 28 VDC Non Essential Bus	
Defog Blower Motors Pwr Overdraw -				5			>5 amps to DISENG light & electro- mechanical control disconnects from the 28 VDC Essen- tial Bus	
DEFOG & VENT						Pri Dir Contr sw at DISENG		
Primary Direction Anti-Torque Sys Pwr Overdraw -	Tripped Crcr Brkr						>5 amps to control relay & possible JAM light & time delay relay, from same source as above	-10, pp 2-10, 20 & 24 (TM 55-1520-228) -23-2, p F-59
PRI DIR CONTR								

Table: C5 (Electrical - Cont'd)

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		NOTE # (SH 7)
	TYPE	RANGE	MARKINGS			CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-235)	
Rpm Sensors (S18 & 91), Audio Warning Device (PS17), Caution Panel Pwr Supply & Dimming Control Pwr Overdraw -	Tripped Crcr Brkr		5	All	>5 amps to sys- from the 28 VDC Essential Bus		-10, pp 2-10, 17, 24 & 28 (TM 55-1520-228) -23-1, p 8-10 -23-2, pp F-27 & 65	
CAUTION PNL LTS					>5 amps to lights from the 28 VDC Essential Bus			
Position Lights Pwr Overdraw -					>15 amps to lights from the 28 VDC Essential Bus			
POS LTS			15				-10, pp 2-10, 24, 26 & 27 (TM 55-1520-228) -23-1, pp 9-57/60 -23-2, p F-31	
Anti-Collision Lights Pwr Overdraw -								
ANTI COLL LTS								
Landing Light Relays (K8 & K9) & Lamps Pwr Overdraw -	Tripped Crcr Brkr		20	All	>20 amps to sys- tem from the 28 VDC Essential Bus			6
LDS LT PWR								
Landing Light Control Sys Pwr Overdraw -			Unknown		Power source unknown			
LDS LT CONT							-10, pp 2-10, 24, 25 & 27 (TM 55-1520-228) -23-1, pp 9-55/57 & 78 -23-2, pp F-29, 61 & 67	
Instrument Light Pwr Supplies (PS1 & 2), Night Vision Goggles Relay (K18) & Caution Lgt Relay (K19) Pwr Overdraw -			3		>3 amps to PS1 & 2 only from the 28 VDC Essential Bus			
INST LTS					>3 amps to all devices (same power source)			



Table: C5 (Electrical - Cont'd)

PARAMETER NAME - INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER		REFERENCES (TM 55-1520-235)	NOTE # (SH 7)
	TYPE	RANGE	MARKINGS			CONDITION TYPE	DURATION		
Night Vision Google Voltage Regulator (VR2) Pwr Overdraw -	Tripped Crcct Brkr		5	Nvg/Normal Lgt switch at NVG	>5 amps to voltage regulator from the 28 VDC Essential Bus				
NVG VR					>5 amps to lights from the 28 VDC Essential Bus				
Console Switches & Equipment Lgts Pwr Overdraw -					>5 amps to light from the 28 VDC Non Essential Bus				
CSL LT					>10 amps to voltage regulator from the 28 VDC Essential Bus				
Cockpit Utility Lgt Pwr Overdraw -									
COCKPIT LTS									
Signal Light Receptacle Pwr Overdraw -			10						7
SIGNAL LT									

NOTES:

1. Sensor is the Voltage Regulator VR1 which energizes the Generator Fail Relay (K11). This relay provides a path to ground at connector P64L on the caution panel.
2. Sensor is the Inverter Fail Relay (K10) which is held open by power from the AC Bus. When bus power fails, relay contacts provide a path to ground at connector P64K on the caution panel.
3. The Operator's Manual specifies three circuit breakers protecting the ammeter. However, the circuit diagram in the last reference shows only two.
4. Circuit breakers are not assigned unique designator numbers on the helicopter. Designators which are used (e.g., CB7, CB5, etc.) are applied to more than one breaker (see TM 55-1520-228-23-2, Appendix F for examples). All circuit breakers are on the overhead breaker panel unless otherwise specified.
5. The combination switch and circuit breaker is located on the overhead console control panel.
6. Since the most recent changes have not been supplied to General Electric for all of the technical manuals on hand, Figure F-37 for TM-1520-228-23-2 is not available, even though it is referenced in TM 55-1520-228-23-1. Thus the current rating and bus connection for the LDG LT CONT circuit breaker is not known.
7. TM 55-1520-235-10 (OH-58C Operator's Manual) p. 2-10 shows this circuit breaker rated at 7.5 amperes, but TM 55-1520-228-10 (OH-58A Operator's Manual) and TM 55-1520-228-23-2, P. F-67 both indicate a 10 ampere rating. It was assumed that the last manual had the most accurate information since it is a maintenance manual, but it is possible that the correct rating is 7.5 amperes.

HELICOPTER: OH-58C

SUBSYSTEM: Miscellaneous

SUBSYSTEM PARAMETER DATA LIST

Table 26  
Sheet No.: 1

PARAMETER NAME- INDICATOR LABEL	INDICATOR			OPERATING MODE	CONDITION	PARAMETER CONDITION TYPE - DURATION	REFERENCES (TM 55-1520-235)	NOTE # (SH 2)
	TYPE	RANGE	MARKINGS					
Primary Directional Anti-Torque System Jammed - JAM	Advisory Light	--	--	Pri Dir Contr Sw in the ENGAGE position	Pedal force on primary control System is <u>50</u> lbs.	Advisory - none specified	-10, pp 2-8/9 & 20 (TM 55-1520-228) -23-2, pp 11-29, 56 & F-59	1
Primary Directional Anti-Torque System Disengaged - DISENG		--	--	Pri Dir Contr Switch at DISENG	Electromechanical control discon- nects have been activated, dis- abling the pri- mary anti-torque system	Advisory - none specified		2

Table: C6 (Miscellaneous - Cont'd)

NOTES:

1. Sensors are two electromechanical control disconnects at opposite ends of the anti-torque system. Each has tension and compression switches which supply power to the JAM light through a 1/2 second time delay network.
2. Sensors are the same as those above, except that the path to ground for electrical power which activates the light is provided by a set of relay activated contacts on each disconnect. The relays are activated by placing the Pri Dir Contr switch at DISENG. A control relay (J517) is used to control electrical paths as a function of the switch position.

SUBSYSTEM PARAMETER DATA LIST  
FOR THE  
YAH-64

# SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: YAH-64

SUBSYSTEM: Engine

Table: D1

Sheet No.: 1

PARAMETER NAME- INDICATOR LABEL		INDICATOR			PARAMETER		REFERENCES (STUDENT MANUAL: EDT-3 TRNG CRSE)	NOTE # (SH 5)
TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	CONDITION TYPE - DURATION		
Engine Power Turbine Speed - ENG-RTR RPM % Np 1(2)	0-120	Segments... (0)G (0-94)R (94-98)A (98-100)G (100-104)A (104-120)R Stripes... (20-40)A (60-90)A (94-98)A (100-104)A	%	All (See Note)	60-90	Cautionary - transient	pp 6-52, 7-8, 12, 13, 16-3 & 20 (PS14-11017C) pp 6, 9 & 15 (PS14-110218) pp 10, 12 & 18 (TM 55-1520-238) -10, pp 5-2, 8-27 & 9-4	1,2,5,6
					98-100	Normal - continuous		
					100	Maximum - continuous		
					113	Maximum - 12 seconds		
				Engines Shut- down, Rotor Brake sw to ON	50	Maximum (for applying rotor brake) - none specified		
ENG 1 (2) OUT	--	Red	%	Eng 1 (2) Power Lever(s) in FLY position	<(93 ±5)	Cautionary - none specified		1,4,7
		--						
Engine Gas Producer Speed - NG RPM % 1 (2)	0-120	Segments... (0)G (0-62)R (62-102)G (102-105)A (105-120)R Stripes... (102-105)A	%	All	67-99	Normal - continuous	pp 6-52, 7-8/11, 16-3 & 20 (PS14-11017C) pp 6, 10 & 14 (TM 55-1520-238) -10, pp 5-3 & 9-4	1,2,5,9
					99-105	Cautionary - 30 minutes		
					105	Maximum - 12 seconds		
NG % RPM/LEFT (RIGHT)	0-999	Red dot to indicate selected parameter						
ENG 1 (2) OUT	--	Red	%	Eng 1 (2) Power Lever(s) in FLY position	<(63 ±10)	Cautionary - none specified		1,10
		--						

Table: D1 (Engine - Cont'd)

PARAMETER NAME - INDICATOR LABEL		INDICATOR			OPERATING MODE	CONDITION	CONDITION TYPE - DURATION	REFERENCES (STUDENT MANUAL : EDT-3 TRNG CRSE)	NOTE # (SH 5)
TYPE	RANGE	MARKINGS	UNITS						
Engine Turbine Gas Temperature - TGT °C X 100 1 (2)	Segmented Vertical Light Bar w/Digital Readout (P)	0-1000	Segments.... (0-775)G (775-840)A (840-1000)R Stripes.... (775-840)A Red Diamond at 880	°C	Starting engine Ng <67%	810	Maximum - transient	pp 6-34, 52 & 7-14/15 (PS14-11017C) pp 5, 6, 9 & 13 (TM 55-1520-238) pp 5-3, 8-19 & 9-8	1,2,5,11
			Engine shut- down (after hot start)		300	Maximum - transient			
TGT °C/LEFT (RIGHT)	Selectable Digital Display (CPG)	0-999	Red dot to indicate selected parameter	Engine running	0-775	Normal - continuous			
					775-850	Cautionary - 30 minutes			
					850	Maximum - transient			
					886	Maximum - 12 seconds			
Engine Torque - TORQUE % 1 (2)	Segmented Vertical Light Bar w/Digital Readout (P & CPG)	0-120	Segments.. (0-100)G (100-120)R "S" at 110	Engine shut- down (in flight)	540	Maximum - transient			
					Dual Engine	0-100	Normal - continuous	pp 6-52, 7-16 & 17 (PS14-11017C)	
						100	Maximum - continuous	pp 6, 9 & 15 (TM 55-1520-238)	
					Single Engine	0-110	Normal - continuous	-10, p 5-1	
						110	Maximum - continuous		
									1,2,5,12

Table: D1 (Engine - Cont'd)

Sheet No.: 3

PARAMETER NAME- INDICATOR LABEL	INDICATOR			PARAMETER			REFERENCES (STUDENT MANUAL: EDT-3 TRNG CRSE)	NOTE # (SH 5)
	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	CONDITION TYPE - DURATION	
Engine Oil Pressure -					Engine start, power lever at Idle			
ENG OIL PSI X 100 1 (2)	Segment Vertical Light Bar (P)	0-220	Segments... (0-20)R (20-40)A (40-100)G (100-120)A (120-220)R Stripes... (20-40)A (100-120)A			>100	Cautionary - 5 minutes	
						25	Minimum - continuous	
					Engine running	25-45	Idle (Ng <85%) - continuous	1,2,5,13
ENG OIL PSI/LEFT (RIGHT)	Selectable Digital Display (CPG)	0-999	Red dot to indicate selected parameter			45-100	Normal (Ng >85%) - continuous	
						100	Maximum (except on start) - continuous	
OIL PRESS ENG 1 (2)	Caution Lgts (2; P)			psi	All		Cautionary - unspecified	1,3,14,15
ENG 1 (2)	Caution Lgts (2; CPG)		Amber			<(20-25)		
Engine Oil Temperature -								
ENG OIL °C X 10 1 (2)	Segmented Vertical Light Bar (P)	-60 - 160	Segments... (-60-30)A (30-135)G (135-150)A (150-160)R Stripes... (135-150)A			35-135	Normal - continuous	
						135-150	Cautionary - transient	1,2,5,16
ENG OIL °C/LEFT (RIGHT)	Selectable Digital Display (CPG)	-99 - 999	Red dot to indicate selected parameter	°C	All	150	Maximum - transient	
OIL HOT ENG 1 (2)	Caution Lgts (2; P)						Cautionary - transient	1,3,17
ENG 1 (2)	Caution Lgts (2; CPG)		Amber			>135		



Table: 01 (Engine - Cont'd)

PARAMETER NAME- INDICATOR LABEL	TYPE	THE LOCATION			OPERATING MODE	CONDITION	CONDITION TYPE - DURATION	REFERENCES (STUDENT MANUAL: ED-3 TPNG CRSE)	NOTE # (SH 5)
		RANGE	MARKINGS	UNITS					
Engine Oil Filter Differential Pressure -	Caution Lgts (2; P)		Amber	psid	All	>(60-80)	Cautionary - transient		1,3,18
OIL FTR BYP ENG 1 (2)	Caution Lgts (2; CPG)							pp 7-19/20, 16-8, 9 816 (PS14-11021B) pp 8, 11, 17 & 18	
Engine Powertrain Integrity - CHIPS ENG 1 (2)	Caution Lgts (2; P)		Amber	--	All	Sensor contacts grounded by metal particles from engine	Cautionary - transient		1,3,19
ENG 1 (2)	Caution Lgts (2; CPG)								
Engine Anti-Ice Bleed Air (GE) Valve Position - ENG 1 (2)	Advisory Lgts (2) on Pilot's Anti-Ice Control Panel		--	--	All	No power to valve	Advisory - none specified	pp 6-44/45 & 15-2/5	1,20
Engine Nose Gearbox/Cross Shaft Fairing Anti-Ice Heating Blanket Temp. - ANTI-ICE HOT ENG INLET	Caution Lgts (1; P & 1; CPG)		Amber	°F	All	>(150 ±5)	Cautionary - none specified	pp 15-6/8, 16-12 & 17 (PS14-11021B) pp 8, 9, 11, 17 & 18	1,3,21
Engine No. 1 Inlet Ice Formation - ENG ICE	Caution Lgt (P)		Amber	--	All	Ice formed on detector probe	Cautionary - none specified	p 16-8 (PS14-11021B) pp 8, 12 & 17	1,20,22
Engine Chop Collar Position - ENGINE CHOP	Warning Lgts (1; P & 1; CPG)		Red	--	All	Engines chopped to idle by crew member	Advisory - none specified	pp 7-6, 7 & 16-3/4 (PS14-11021B) pp 10, 11 & 18	1,3,7
	Tone in ICS CP & CPG		--	--					1,8

Table: D1 (Engine - Cont'd)

## NOTES:

1. The terms "P" & "CPG" refer to the Pilot's and Copilot/Gunner's crew stations, respectively. In the case of indicator lights, the number of lights at the particular crew station precedes the crew station designation along with a semicolon.
2. TM 55-1520-238-10 is a preliminary Operator's Manual, dated 31 May 1979. Much of the data which describes specific parameter conditions in conjunction with operating modes is yet to be supplied following flight testing. PS14-11017C is a Hughes Helicopter performance specification for engine, rotor and fuel quantity instruments, dated 10 Nov. 1977.
3. Sensor is a mechanical switch which has a closed (fault condition) resistance of 10 ohms maximum and an open resistance of 2 megohms minimum. The maximum voltage and current with the switch closed are 0.1 VDC and 5-7 milliamperes respectively, while the switch open values are +5 to 30 VDC (positive) and 25 microamperes respectively.
4. Sensor is a solid state switch which, when closed (turned on - fault condition), allows the light circuitry to see a maximum of +0.5 VDC and can sink 5-10 milliamperes (max). When the switch is open, the voltage at the light circuit is 5-30 VDC (positive) with a maximum current flow of 25 microamperes.
5. The indicator light segments are colored red (R), amber (A) or green (G). As the parameter value passes from one color range to the next, the preceding range disappears as the first segment in the new color range lights up. Since the only indication of impending operation in a red or amber zone is by remembering where these zones begin and/or the green zones end, the manufacturer has also placed stripes alongside of the light bars, to indicate amber segment ranges plus possible transient operating zones which are shown as red segments on the instrument itself.
6. The indicator accuracy is within 1% full scale. The sensor is a tachometer generator producing a single phase ac square wave with pulse widths of 200  $\pm$  50 microseconds and peak to peak voltage of 4.0  $\pm$  0.2 volts over a full speed range of 6,000-25,000 rpm. The pulse frequency at 20,952 rpm (100% Np) is 1396.76 Hz with no error. When torque is increased from a zero load condition, every other pulse will experience a shift in phase from its epoch value of up to 20%. Total load impedance presented by both indicators to an individual rpm sensor is a minimum of 20K ohms resistance and a maximum of 0.004 microfarads capacitance.
7. The warning lights flash at a 2  $\pm$  1 Hertz rate until the master caution light is pressed, at which point the lights are steadily illuminated, for that particular crew station.
8. The aural tone is a 700-1700 Hz sweep tone which can be reset from either crew station by pressing the corresponding warning light.
9. Indicator inaccuracy is  $\pm$  1% of full scale. Sensor is a tachometer generator producing a single phase, 2V<sub>p-p</sub> signal at 2235 rpm increasing to 75 V<sub>p-p</sub> at 44,700 rpm. Signal frequency is 2135.7 Hz at 44,700 rpm (100%). Minimum resistive load presented to sensor by both indicators is 10K ohms, and maximum capacitive impedance load presented to the sensor is 0.01 microfarad.
10. Warning lights are the same as those described for the power turbine speed.
11. The starting limit Ng condition is a best guess, since the Operator's Manual specifies "idle speed" but does not say what that is. The pilot's indicator is accurate to  $\pm$  5% full scale. The copilot/gunner's indicator has that accuracy over the 501°C to 1000°C range, and it is accurate to  $\pm$  10°C from 0°C to 500°C. Sensors consist of seven alumel-chromel thermocouples in each engine. Signal levels are in accordance with NBS-CIRC-561 Table 6, March 1974, Thermocouple Reference Table. The thermocouple network maximum resistive impedance is 690 ohms. The minimum indicator load impedance is 1.5 megohms.
12. The indicator accuracy is  $\pm$  1% over the full range. Torque signal scale factor is 1.0 VDC/100 ft-lbs of torque, with a 0.25V<sub>p-p</sub> maximum ripple at a frequency of 333 Hz for an Np speed of 10,000 rpm. If the Np speed is doubled, the maximum ripple decreases to 0.1V<sub>p-p</sub> at 660 Hz. For single engine operation, the normalized 100% torque equates to 391 foot-pounds of actual power turbine torque. The normalized 100% value for dual engine operation equates to 709 foot-pounds engine power. (This may in fact be total power from both engines, but this is not so stated in the procurement specification.) Total indicator load resistance is at least 100K ohms.

Table: D1 (Engine - Cont'd)

NOTES (Cont'd):

13. The indicator markings used are based on those in the student manual and procurement specifications. The indicator range shown in the Operator's Manual is 0-120 psi and the markings are more in line with operating limits (for the same engine) which are detailed for the UH-60A. Since the procurement specification was obtained directly from Hughes Helicopters it is presumed that that document contains the most current information on the actual indicator. The sensor is a pressure transducer producing a dc voltage which varies linearly from 0 to 5 ( $\pm 0.025$ ) volts for a pressure range of 0 to 220 psig. The maximum signal ripple is 20 millivolts peak-to-peak. The transducer requires an excitation signal of  $28 \pm 4$  VDC, 50 milliamperes maximum. The output impedance of the transducer is less than 1 ohm. The 0-220 psig range corresponds to 2.5 to 97.5% ( $\pm 2.5\%$ ) of the full scale range of the transducer. The indicator accuracy is  $\pm 1\%$  full scale. Ng speed at idle is indicated as  $\leq 87\%$  in the Operator's Manual but is listed as  $\leq 85\%$  in the first of the detailed references.
14. The increasing pressure (switch open) threshold given in the first reference is 23-28 psi. However, the Operator's Manual indicates this threshold is 35-40 psi (p 8-21). The 23-28 psi threshold is more likely, since it is consistent with the turn on threshold. The turn on threshold is itself consistent with the minimum continuous analog signal condition (25 psig).
15. PS14-110218 is a Hughes Helicopter procurement specification for the caution and warning displays, dated 25 Oct 1977.
16. Sensor is part of a combined switch and analog transmitter unit, where the switch operates the OIL HOT caution lights. The analog transmitter is an HS28034-3 resistance bulb. The indicator accuracy is  $\pm 3^\circ\text{C}$ .
17. The turn-off (decreasing temperature) switch threshold is  $118^\circ\text{C}$ .
18. The turn-on, turn-off thresholds are both within the 60-80 psid range. Light indicates filter bypass is pending.
19. Exact chip detector sensor operating mechanism is not described but suspect a magnetic plug to attract and hold ferrous metal particles close to the switch contacts, thereby creating a path to ground.
20. Sensor type and operating mode information is not contained in the available literature.
21. The decreasing temperature (light turn-off) threshold is  $140^\circ \pm 5^\circ\text{F}$ .
22. Light is activated by a 28 VDC signal from the sensing device to the caution/advisory panel. In the high stage, the fault signal source output voltage is 16-30 VDC with load currents of 5 milliamperes to 10 milliamperes respectively. The rise time is from 1 to 20 microseconds. In the no fault case (low state) the output voltage is 0-0.5 VDC.

SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: YAH-64

Table: D2

SUBSYSTEM: Fuel

Sheet No.: 1

INDICATOR			PARAMETER			REFERENCES (STUDENT MANUAL: EDT-3 TRNG CRSE)	NOTE # (SH 3)
PARAMETER NAME- INDICATOR LABEL	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	CONDITION TYPE - DURATION
Fuel Qty, Fwd & Aft Tanks -	Segmented Vertical Light Bar w/Digital Readout of Total Fuel (P)	FWD 0-1000 AFT 0-1400	Fwd Segments... (0-10)R (10-20)A (20-100)G Aft Segments... (0-10)R (10-20)A (20-140)G			0-(210 ±10) Fwd 0-(245 ±10) Aft	Cautionary - none specified. (However this gives about a 30 minute reserve at cruise power)
FUEL LB X 10 FWD (AFT)						(210 ±10) - 981.5 Fwd	pp 4-6, 8, 12, 14, 16-10 & 17 (PS14-11017C) pp 6/8, 10, 11 & 16 (PS14-11021B) pp 8, 9, 11, 17 & 18
FUEL QTY LBS X 10/FWD (AFT)	Selectable Digital Display (CPG)	0-999	Red dot to indicate selected parameter	lbs	All	(245 ±10) - 1417 Aft	
FUEL LOW FWD (AFT)	Caution Lgts (2; P & 2; CPG)	--	Amber	lbs	All	≤(210 ±10) Fwd ≤(245 ±10) Aft	1,3,4, 6,7 1,3,5,8
Boost Pump Pressure - ENG	Discrete Light on Pilot's Fuel Control Panel	--	Green	--	Boost pump ON (Boost Pump SW or Eng. Start SW ON)	Engine fuel line pressurized	pp 4-2, 3 & 14 (TM 55-1520-238) -10, Fig 1-1, View BB
Engine Fuel Filter Differential Pressure - FUEL FTR BYP ENG 1 (2)	Caution Lgts (2; P)		Green	psid	All	≥7.5	pp 7-26/27, 16-9 & 16 (PS14-11021B) pp 8, 9, 11, 17 & 18
ENG 1 (2)	Caution Lgts (2; CPG)						Cautionary - none specified

Table: D2 (Fuel - Cont'd)

PARAMETER NAME- INDICATOR LABEL	INDICATOR				PARAMETER				NOTE # (SH 3)
	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	CONDITION TYPE - DURATION	REFERENCES (STUDENT MANUAL : EDT-3 TRNG CRSE)	
Transfer Refueling Valve Position - REFUEL VALVE	Caution Lgt (P)		Amber	--	All	Valve is open (commanded by switch on refueling panel)	Advisory - none specified	pp 4-7, 13 & 19 (PS14-11021B) pp 8, 11 & 17	1,4,5, 10
Fuel Qty, External Tanks - EMPTY EXT TANKS	Caution Lgt (P)		Amber	lbs	All	Tanks empty	Cautionary - none specified	p 16-11 (PS14-11021B) pp 8, 11 & 17	1,4,5
Engine Fuel Pump Pressure - FUEL PRESS ENG 1 (2)	Caution Lgts (2; P)		Red	psi	All	Low output pres- sure on engine driven fuel pump	Warning - none specified	(PS14-11021B) pp 8, 11 & 18	1,4,5, 11

## NOTES:

1. The terms "P" & "CPG" refer to the Pilot's and Copilot/Gunner's crew stations, respectively. In the case of indicator lights, the number of lights at the particular crew station precedes the crew station designation along with a semicolon.
2. TM 55-1520-238-10 is a preliminary Operator's Manual, dated 31 May 1979. Much of the data which describes specific parameter conditions in conjunction with operating modes is yet to be supplied following flight testing.
3. PS14-11017C is a Hughes Helicopter performance specification for engine, rotor and fuel quantity instruments, dated 10 Nov. 1977.
4. PS14-110218 is a Hughes Helicopter procurement specification for the caution and warning displays, dated 25 Oct 1977.
5. Sensor is a mechanical switch which has a closed (fault condition) resistance of 10 ohms maximum and an open resistance of 2 megohms minimum. The maximum voltage and current with the switch closed are 0.1 VDC and 5-7 milliamperes respectively, while the switch open values are 5 to 30 VDC (positive) and 25 microamperes respectively.
6. The indicator light segments are colored red (R), amber (A) or green (G). As the parameter value passes from one color range to the next, the preceding range disappears as the first segment in the new color range lights up.
7. Indicator accuracy depends on flight attitude. For all indicators the accuracy is 2% of indicated value plus 1% of full scale value, for sustained flight attitudes. For normal flight attitudes, accuracy is 1% of full scale. Sensors are capacitance type probes, two in the forward cell and one in the aft cell. The signal parameters are not specified in the available references, but may be shown on Hughes Helicopters drawings 7-211642077 and 7-211642076. These drawings were not available to GE.
8. The actual low level detection is accomplished with thermistor bead type sensors on a fuel quantity probe in each tank. The signal from the beads activates a mechanical switch. The switch presumably would have the resistance characteristics specified in note 5 above, yet PS14-11017C indicates an open switch resistance of 500-650 ohms. Clarification would be required prior to designing an interface to that circuit.
9. Sensor type and signal path not specified in available literature. Altitude limit for "boost pump out" operation is not above 10,000' pressure altitude.
10. Valve provides a shunt path around the transfer pump.
11. No other references mention monitoring this parameter, yet all the pictures of the pilot's caution panel show these segments. If the engine fuel pressure is lost, the engine will flame out. However, no reference indicates at what fuel pump pressure an actual flame out occurs, or at what pressure the lights are activated.

# SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: YAH-64

Table: D3

SUBSYSTEM: Powertrain

Sheet No.: 1

INDICATOR		PARAMETER			OPERATING MODE	UNITS	REFERENCES (STUDENT MANUAL: EDT-3 TRNG CRSE)	NOTE # (SH 4)
PARAMETER NAME- INDICATOR LABEL	TYPE	RANGE	MARKINGS	CONDITION				
Main Rotor Speed -	Segmented Vertical Light Bar (Part of Engine/Rotor Tachometer - P & CPG)	0-120	Segments... (0-94)R (94-104)G (104-120)R	94	Powered Flight	%	pp 9-14, 16-3, 5 & 20 (PS14-11017C) pp 6, 8, 10 & 15 (PS14-110218) pp 10, 12, & 18 (TM 55-1520-238) -10, p 5-2	1,2,3, 6,9
ENG RTR RPM %				94-104				
				104				
				94-104				
				115				
LOW RPM ROTOR	Warning Lgts (1; P & 1; CPG) Tone in ICS (P & CPG)		Red	<90.3	All			1,5,7
HIGH RPM ROTOR	Warning Lgts (1; P & 1; CPG) Tone in ICS (P & CPG)		Red	>104				1,5,8
Main Transmission Oil Pressure (Galleries 1 & 2) -	Cauton Lgts (2; P)							
OIL PRES MM XMS 1 (2)								
MAIN XMSN 1 (2)	Cauton Lgts (2; CPG)							
Main Transmission Accessory Gearbox Oil Pressure -	Cauton Lgt (P)							
OIL PRES ACC PMP								
			Amber	<(28 ±2)	All	psi	pp 9-14, 18, 24, 25, 16-10 & 17 (PS14-110218) pp 8, 9, 11, 17 & 18	1,3,4, 10

Table: D3 (Powertrain - Cont'd)

Sheet No.: 2

INDICATOR			PARAMETER				REFERENCES (STUDENT MANUAL: EDT-3 TRNG CRSE)	NOTE # (SH 4)
PARAMETER NAME- INDICATOR LABEL	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	CONDITION TYPE - DURATION	
Main Transmis- sion Oil Temp. (Galleries 1 & 2) -	Caution Lgts (2; P)		Amber	°F	All	$\geq (284 \pm 10)$	Cautionary - none specified	1,3,4, 11
OIL TEMP MM XMSN 1 (2)								
MAIN XMSN 1 (2)	Caution Lgts (2; CPG)							
Main Transmis- sion Oil Qty (Galleries 1 & 2) -	Caution Lgts (2; P)		Amber	--	All	Oil quantity in affected gallery sufficiently low so as to cause diverter valve to close	Cautionary - none specified (but see note 12)	1,3,4, 12
OIL LOW MM XMSN 1 (2)								
MAIN XMSN 1 (2)	Caution Lgts (2; CPG)							
Nose Gearbox Oil Pressure -								
OIL PRES NS GRBX 1 (2)	Caution Lgts (2; P)		Amber	psi	All	$\leq (28 \pm 2)$	Cautionary - none specified (but see note)	1,3,4, 10
ENG 1 (2)	Caution Lgts (2; CPG)							
Nose Gearbox Oil Temp -								
OIL HOT NOSE GRBX 1 (2)	Caution Lgts (2; P)		Amber	°F	All	$\geq (284 \pm 10)$	Cautionary - none specified	1,3,4, 11
ENG 1 (2)	Caution Lgts (2; CPG)							



Table: D3 (Powertrain - Cont'd)

Sheet No.: 3

PARAMETER NAME - INDICATOR LABEL	INDICATOR			PARAMETER			NOTE # (SH 4)
	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	
Intermediate Tail Rotor Drive Gearbox Temp. - INTND GRBX	Caution Lgt (P)						
	Caution Lgt (CPG)		Amber	°F	All	>(285 ±28)	pp 9-36/39 & 16-10 (PS14-110218) pp 8, 12 & 17
	Caution Lgt (P)						1,3,4, 13
	Caution Lgt (CPG)						
Tail Rotor (90°) Gearbox Temp. - TAIL GRBX	Caution Lgt (P)						
	Caution Lgt (CPG)						
	Caution Lgt (P)						
	Caution Lgt (CPG)						
Gearbox Integrity - CHIPS MAIN XMSN	Caution Lgts (1; P & 1; CPG)					Sensor contacts grounded by metal particles from main transmission	
	Caution Lgts (2; P)		Amber	--	All	Sensor contacts grounded by metal particles from engine noise gearbox	pp 9-6/9, 14, 18, 24, 25, 36/39 & 16-9/17 (PS14-110218) pp 8, 12 & 17
	Caution Lgts (2; CPG)						1,3,4, 14
	Caution Lgt (P)						
Rotor Brake Sw Activation - ROTOR BRAKE	Caution Lgt (P)		Amber	--	Engines OFF, Ng ≤50%	Rotor brake sw is in ON or LOCK position	pp 9-28/29 & 16-19 (PS14-110218) pp 8, 12 & 17 (TM 55-1520-238) -10, pp 8-19/21
					All other modes	Cautionary - none Specified	1,2,3, 15

NOTES:

1. The terms "p" & "CPG" refer to the Pilot's and Copilot/Gunner's crew stations, respectively. In the case of indicator lights, the number of lights at the particular crew station precedes the crew station designation along with a semicolon.
2. TM 55-1520-238-10 is a preliminary Operator's Manual, dated 31 May 1979. Much of the data which describes specific parameter conditions in conjunction with operating modes is yet to be supplied following flight testing. PS14-11017C is a Hughes Helicopter performance specification for engine, rotor and fuel quantity instruments, dated 10 Nov. 1977.
3. PS14-11021B is a Hughes Helicopter procurement specification for the caution and warning displays, dated 25 Oct 1977.
4. Sensor is a mechanical switch which has a closed (fault condition) resistance of 10 ohms maximum and an open resistance of 2 megohms minimum. The maximum voltage and current with the switch closed are 0.1 VDC and 5-7 milliamperes respectively, while the switch open values are 5 to 30 VDC (positive) and 25 microamperes respectively.
5. Sensor is a solid state switch which, when closed (turned on - fault condition), allows the light circuitry to see a maximum of +0.5 VDC and can sink 5-10 milliamperes (max). When the switch is open, the voltage at the light circuit is 5-30 VDC (positive) with a maximum current flow of 25 microamperes.
6. The indicator light segments are colored red (R), amber (A) or green (G). As the parameter value passes from one color range to the next, the preceding range disappears as the first segment in the new color range lights up. Since the only indication of impending operation in a red or amber zone is by remembering where these zones begin and/or the green zones end, the manufacturer has also placed stripes alongside of the light bars, to indicate amber segment ranges plus possible transient operating zones which are shown as red segments on the instrument itself.
7. The warning lights flash at a  $2 \pm 1$  Hertz rate until the master caution light is pressed, at which point the lights are steadily illuminated, for that particular crew station.
8. The aural tone is a 700-1700 Hz sweep tone which can be reset from either crew station by pressing the corresponding warning light.
9. Indicator has a full scale accuracy of 1%. The sensor consists of a magnetic pickup mounted adjacent to the rotor brake. The signal to the indicator is a single phase ac signal with no separation between the positive and negative components in each period. At 100% Ng, the signal frequency is 1348 Hz (376 microsecond pulse width) with an amplitude of 3V<sub>p-p</sub>. At 120% Ng, the frequency is 1618 Hz (209 microsecond pulse width) with an amplitude of 3.5V<sub>p-p</sub>. The total indicator impedance (both instruments) presented to the sensor is a minimum of 20K ohms resistive.
10. The light turn-off (increasing pressure) threshold is 45 psi. The actual analog pressure is possibly available on the multiplex bus. (Reference PS14-11021B, p 9-24.) Due to incorporation of wicking, the transmission can run at reduced power for 1/2 hour after loss of oil pressure.
11. Same as above except the light turn-off threshold is  $254^\circ \pm 10^\circ\text{F}$ .
12. Available references do not specify what volume of remaining oil causes the diverter valve to close. Same time limit applies as in note 10 above.
13. The light turns off when the temperature goes below the maximum limit (but the number is not specified). The Fault Detection/Location Subsystem also monitors vibration (acceleration) levels in the gearbox. The CPG caution light illuminates for an overtemperature in either gearbox.
14. Exact chip detector sensor operating mechanism is not described but suspect a magnetic plug to attract and hold ferrous metal particles close to the switch contacts, thereby creating a path to ground.
15. Light is activated by a 28 VDC signal from the sensing device to the caution/advisory panel. In the high state, the fault signal source output voltage is 16-30 VDC with load currents of 5 milliamperes to 10 milliamperes respectively. The rise time is from 1 to 20 microseconds. In the no fault case (low state) the output voltage is 0-0.5 VDC.

# SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: YAH-64

Table: D4

SUBSYSTEM: Hydraulic

Sheet No.: 1

INDICATOR				PARAMETER			REFERENCES (STUDENT MANUAL : EDT-3 TRNG CRSE)	NOTE # (SH 3)
PARAMETER NAME- INDICATOR LABEL	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	CONDITION TYPE - DURATION	
Primary Hydraulic Pump Pressure - HYD PRI	Semicircular Gauge (shared w/Utility System)	0-6000	(Unavailable)	psi	All	3000-3250	Normal - continuous	1,2,3,6
						3250	Maximum - continuous	
	Caution Lgt (P)		Amber			<1250	Cautionary - none specified	pp 11-4, 8, 16-11 & 15 (PS14-110218) pp 8, 9, 11, 17 & 18 (TM 55-1520-238) -10, p 5-4
OIL PRESS PRI HYD	Caution Lgt (CPG)							
PRI HYD					OAT > (100° ±15°F)	< (60-80)	Cautionary - none specified	1,3,4,8
Primary Hydraulic Manifold Filter Differential Pressure - OIL FTR BYP PRI HYD	Caution Lgt (P)		Amber					
Primary Hydraulic Manifold Reservoir Fluid Qty - OIL LOW PRI HYD	Caution Lgt (P)		Amber	--	All	Oil down to low level mark in reservoir	Cautionary - none specified	1,3,4,9
Utility Hydraulic Pump Pressure - HYD UTIL	Semicircular Gauge (shared w/Primary System)	0-6000	(Unavailable)	psi	All	3000-3250	Normal - continuous	1,3,6
						3250	Maximum - continuous	
OIL PRES UTIL HYD	Caution Lgt (P)		Amber			<1250	Cautionary - none specified	pp 11-6 & 16-11 (PS14-110218) pp 8, 11 & 17
UTIL HYD	Caution Lgt (CPG)							1,3,4,7

Table: D4 (Hydraulic - Cont'd)

Sheet No.: 2

INDICATOR				PARAMETER			REFERENCES (STUDENT MANUAL: EDT-3 TRNG CRSE)	NOTE # (SH 3)
PARAMETER NAME - INDICATOR LABEL	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	CONDITION TYPE - DURATION	
Utility Hydraulic Manifold Filter Differential Pressure - OIL FTR BTP UTL HYD	Caution Lgt (P)		Amber	psi	OAT >(100° ±15°F)	≤(60-80)	Cautionary - none specified	1,3,4,8
Utility Hydraulic Manifold Reservoir Fluid Qty - OIL LOW UTL HYD	Caution Lgt (P)		Amber	--	All	Oil down to low level mark in reservoir	Cautionary - none specified	1,3,4,9
Utility Hydraulic Fluid Accumulator Pressure - UTL ACC	Circular Gauge	0-4000	(Unavail- able)	psi	All	3000-3250	Normal - continuous	pp 11-20 & 21 (TM 55-1520-238) -10, pp 1-3
						3250	Maximum - continuous	

NOTES:

1. The terms "P" & "CPG" refer to the Pilot's and Copilot/Sumner's crew stations, respectively. In the case of indicator lights, the number of lights at the particular crew station precedes the crew station designation along with a semicolon.
2. TM 55-1520-238-10 is a preliminary Operator's Manual, dated 31 May 1979. Much of the data which describes specific parameter conditions in conjunction with operating modes is yet to be supplied following flight testing.
3. PS14-110218 is a Hughes Helicopter procurement specification for the caution and warning displays, dated 25 Oct 1977.
4. Sensor is a mechanical switch which has a closed (fault condition) resistance of 10 ohms maximum and an open resistance of 2 megohms minimum. The maximum voltage and current with the switch closed are 0.1 VDC and 5-7 milliamperes respectively, while the switch open values are 5 to 30 VDC (positive) and 25 microamperes respectively.
5. Sensor is a solid state switch which, when closed (turned on - fault condition), allows the light circuitry to see a maximum of +0.5 VDC and can sink 5-10 milliamperes (max). When the switch is open, the voltage at the light circuit is 5-30 VDC (positive) with a maximum current flow of 25 microamperes.
6. Sensor and signal information is not contained in available references. Normal pump pressure is regulated to 3000 psi. Over pressure protection is provided by a high pressure relief valve in the manifold that cracks at 3500 psi and closes at 3300 psi.
7. The light turn-off (increasing pressure) threshold is 2050 psi.
8. The light will not turn off until the filter has been removed, cleaned and restored.
9. Exact quantity remaining in reservoir for light activation not specified.
10. The parameter conditions/types are best estimates, based on those of the utility hydraulic system (see note 6 above.)

# SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: YAH-64

Table: D5

SUBSYSTEM: Electrical

Sheet No.: 1

PARAMETER NAME- INDICATOR LABEL	INDICATOR			PARAMETER			REFERENCES (STUDENT MANUAL: EDT-3 TRNG CRSE)	NOTE # (SH 3)
	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	CONDITION TYPE - DURATION	
Generator A Phase Feeder Current - KVA SYS 1 (2)	Circular Dial (P)	0-25	None	Amps	All	Not specified	Not specified	1,3,5, 6
Generator Output Suitability - GEN 1 (2)	Caution Lgts (2; P)		Amber	--	No weight on wheels	1. Volts out >125 VAC, each phase to ground, or 2. Volts out <90 VAC for more than 15 sec- onds, or 3. Feeder current >25 amps on any phase	pp 8-5, 8, 9, 18/21 & 16-13 (PS14-11021B) pp 8, 11 & 17 (Hughes Drawing) #7-211B21004C	1,3,4
					Weight on wheels	Conditions 1 or 3 above or freq. out <380 Hz for more than 2 ±1 seconds		
AC External Pwr Receptacle Door - EXT PWR	Caution Lgt (P)		Amber	--	All	Door is open	Cautionary - none specified	
Transformer/ Rectifier Output Current - DC AMP SYS 1 (2)	Circular Dial (P)	0-200	None	Amps	All	Not specified	Not specified	1,3,5, 7

Table: D5 (Electrical - Cont'd)

Sheet No.: 2

INDICATOR			PARAMETER			REFERENCES (STUDENT MANUAL: EDT-3 TRNG CRSE)	NOTE # (SH 3)
PARAMETER NAME- INDICATOR LABEL	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	CONDITION TYPE - DURATION
AC Essential Bus B Phase or Transformer/ Rectifier Voltage Suitability - RECT 1 (2)	Cauton Lgts (2; P)	--	Amber	Volts	All	Low voltage on the respective AC bus or low volt- age on the respec- tive transformer/ rectifier output line	Cautionary - none specified
FAIL ELEC SYS	Cauton Lgt (CP6)					Low voltage on both AC busses or both transformer/ rectifiers	
Transformer/ Rectifier Operating Temperature - HOT RECT 1 (2)	Cauton Lgts (2; P)	--	Amber	°C	All	≥190	Cautionary - none specified
Battery Temperature - HOT BAT	Cauton Lgt (P)	--	Amber	°C	All	>(57 ±3)	
Battery Charger Status - CHARGER	Cauton Lgt (P)	--	Amber	--	All	Battery not being charged	Cautionary - none specified
Transformer/ Rectifier AC Pwr Overdraw - XFRM RECT 1 (2)	Tripped Crcrt Brkrs (CB1 & CB4; P)		35			>35 amps to the re- spective trans- former/rectifier, from the respec- tive AC Essential Bus	
Generator 1 (2) Contactor AC Bus Cross Tie Relay Pwr Overdraw - GEN 1 (2)	Tripped Crcrt Brkrs (CB2 & CB3; P)		5	Amps	All	>5 amps to the #1 & #2 contactors from the #2 & #1 DC Essential Bus- ses, respectively	Cautionary - none specified
Battery Charger Pwr Overdraw - BATT CHGR	Tripped Crcrt Brkr (CB5; P)		20			>20 amps to the charger from the #1 DC Essential Bus	

Table: DS (Electrical - Cont'd)

NOTES:

1. The terms "P" & "CPS" refer to the Pilot's and Copilot/Gunner's crew stations, respectively. In the case of indicator lights, the number of lights at the particular crew station precedes the crew station designation along with a semicolon.
2. TM 55-1520-238-10 is a preliminary Operator's Manual, dated 31 May 1979. Much of the data which describes specific parameter conditions in conjunction with operating modes is yet to be supplied following flight testing.
3. PS14-11021 is a Hughes Helicopter procurement specification for the caution and warning displays, dated 25 Oct 1977.
4. Sensor is a mechanical switch which has a closed (fault condition) resistance of 10 ohms maximum and an open resistance of 2 megohms minimum. The maximum voltage and current with the switch closed are 0.1 VDC and 5-7 milliamperes respectively, while the switch open values are 5 to 30 VDC (positive) and 25 microamperes respectively.
5. Although this instrument is discussed by the first and third cited references, it is not mentioned or illustrated in the cockpit instrumentation diagrams available in the Operator's Manual. The minimum, maximum and/or normal operating ranges are not mentioned in the available references.
6. Sensing is accomplished using a transformer type coupling.
7. Sensing is accomplished using a resistive shunt.
8. No light out (decreasing temperature) threshold is given. A hot condition is generally indicative of a transformer/rectifier cooling fan failure.
9. The light turn off (decreasing temperature) threshold is  $49^{\circ} \pm 3^{\circ}\text{C}$ . The light on condition also indicates that the battery charger is cut off (at  $50^{\circ} \pm 3^{\circ}\text{C}$  battery temperature).
10. System verification documentation is available only for those circuit breakers listed.



HELICOPTER: YAH-64

SUBSYSTEM PARAMETER DATA LIST

Table: D6  
Sheet No.: 1

SUBSYSTEM: Miscellaneous

PARAMETER NAME- INDICATOR LABEL	INDICATOR				PARAMETER		REFERENCES (STUDENT MANUAL: EDT-3 TRNG CRSE)	NOTE # (SH 4)
	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	CONDITION TYPE - DURATION	
Shaft Driven Compressor Discharge Pressure - SHAFT DRIVEN COMP	Caution Lgt (P)		Amber	psi	All	$\leq (2 \pm 1)$	Cautionary - none specified	1,3,6
Environmental Control Unit Output Air Temp. - ECS	Caution Lgt (P)		Amber	°F	All	$> (220 \pm 20)$	Cautionary - none specified	1,3,7,8
Canopy Temp. and/or Canopy Anti-Ice Heating Element, Sensor & Controller Condition - ANTI-ICE HOT CANOPY	Caution Lgt (P)		Amber	--	Canopy Anti-Ice SW ON	1. Canopy temp. $> 98 \pm 3^\circ\text{F}$ , or 2. Sensor or heating element open or shorted, or 3. Controller failed	Cautionary - none specified	1,3,5,9
Blade De-Ice Heater Time Schedule, Control Unit Temp., Ground Current Leakage and/or Heater Current - FAIL BLADE DE-ICE	Caution Lgt (P)		Amber	--	Blade De-Ice SW ON	1. Heater on/off $\pm 5\%$ out of schedule, or 2. Control unit temp. $> 55^\circ\text{C}$ , or 3. Ground current $> 1.5$ amps, or 4. Heater current $\pm 24\%$ of nominal value	Cautionary - none specified	1,3,5,10

Table: D6 (Miscellaneous - Cont'd)

PARAMETER NAME - INDICATOR LABEL	INDICATOR			PARAMETER				REFERENCES (STUDENT MANUAL: EDT-3 TRNG CRSE)	NOTE # (SH 4)
	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	CONDITION TYPE - DURATION		
Canopy Door Condition - CANOPY	Caution Lgt (P)		Amber	--	All	Either canopy door not closed	Cautionary - none specified	p 16-11 (PS14-11021B) pp 8, 11 & 17	1,3,4
Pitch, Roll & Yaw Stability Command Augmentation System (SCAS) Channels Operating Status - SAS	Caution Lgts (1; P & 1; CP6)		Amber	--	All (ex- cept YAW channel disen- gaged on ground by squat switch)	Channel(s) dis- engaged	Cautionary - none specified	pp 13-10/15 & 16-8 (PS14-11021B) pp 8, 9, 12, 17 & 18	1,3,5, 11
Force Feel Sys Status - F FEEL	Caution Lgt (P)		Amber	--	Force Feel sw ON	System inoperative	Cautionary - none specified		
Back Up Control Sys Status - BUC ON	Advisory Lgt (P)		Green	--	Not specified	System operative	Advisory - none specified	pp 11-12 & 16-8 (PS14-11021B) pp 8, 9, 12, 17 & 18	1,3,5, 12
BUC FAIL	Caution Lgt (P)		Red	--		System inoperative	Cautionary - none specified		
Tail Wheel Lock Condition - TAIL WHEEL	Discrete Light on Pilot's Inst. Pnl.		Green	--	All	Tail wheel unlocked	Advisory - unspecified	pp 3-8, 9 (TM 55-1520-238) -10, Fig. 1-1	2,13
Stabilator Sys Status - STAB FAIL	Caution Lgts (1; P & 1; CP6)		Amber	--	Not specified	Not specified	Not specified	pp 16-8 & 15 (PS14-11021B) pp 8, 9, 11, 17 & 18	1,3,5, 13
Infrared Jam Status - IR JAM	Caution Lgt (P)		Amber	--					

Table: D6 (Miscellaneous - Cont'd)

Sheet No.: 3

PARAMETER NAME- INDICATOR LABEL	INDICATOR			PARAMETER			REFERENCES (STUDENT MANUAL: EDT-3 TRNG CRSE)	NOTE # (SH 4)
	TYPE	RANGE	MARKINGS	UNITS	OPERATING MODE	CONDITION	CONDITION TYPE - DURATION	
Transponder Mode & Integration Reply Status - IFF	Caution Lgts (1; P & 1; CPG)		Red	--	Trans- ponder Mode 4 selected ON	No reply	Cautionary - none specified	1,3,7, 13
Armaments, Fire Control & Sys Status -	Voice Security Caution Lgts (1; P & 1; CPG)							
ROCKET								
GUN								
MISSILE								
TADS								
VOICE CIPHER	Caution Lgt (CPG)		Amber	--	Not specified	Not specified	Not specified	1,3,6, 14
PNVS	Caution Lgt (P)							1,3,7, 14
Flight Control Computer Status - PRI MUX	Caution Lgts (1; P & 1; CPG)		Amber	--	MUX Control sw at PRI	FCC Primary MUX failed & Backup Bus controller (BBC)/Backup MUX operating	Cautionary - none specified	1,3,7

Table: D6 (Miscellaneous - Cont'd)

NOTES:

1. The terms "p" & "CPG" refer to the Pilot's and Copilot/Gunner's crew stations, respectively. In the case of indicator lights, the number of lights at the particular crew station precedes the crew station designation along with a semicolon.
2. TM 55-1520-238-10 is a preliminary Operator's Manual, dated 31 May 1979. Much of the data which describes specific parameter conditions in conjunction with operating modes is yet to be supplied following flight testing.
3. PS14-110218 is a Hughes Helicopter procurement specification for the caution and warning displays, dated 25 Oct 1977.
4. Sensor is a mechanical switch which has a closed (fault condition) resistance of 10 ohms maximum and an open resistance of 2 megohms minimum. The maximum voltage and current with the switch closed are 0.1 VDC and 5-7 milliamperes respectively, while the switch open values are 5 to 30 VDC (positive) and 25 microamperes respectively.
5. Sensor is a solid state switch which, when closed (turned on - fault condition), allows the light circuitry to see a maximum of +0.5 VDC and can sink 5-10 milliamperes (max). When the switch is open, the voltage at the light circuit is 5-30 VDC (positive) with a maximum current flow of 25 microamperes.
6. Turn off (increasing pressure) threshold is 8 psi.
7. Light is activated by a 28 VDC signal from the sensing device to the caution/advisory panel. In the high state, the fault signal source output voltage is 16-30 VDC with load currents of 5 milliamperes to 10 milliamperes respectively. The rise time is from 1 to 20 microseconds. In the no fault case (low state) the output voltage is 0-0.5 VDC.
8. Turn off (decreasing temperature) threshold is 180°F.
9. No turn off threshold is given. Also the listed operating mode is implied by the system description but not specifically stated.
10. The system operation is not described in the available references.
11. The Built-In-Test equipment for the Automatic Stabilization Equipment (ASE) also can cause a SCAS channel disconnect through detection of a servo mistrack (continuous performance monitoring) or incorrect response to a preprogrammed input set (self test - pilot selected).
12. These signals are not currently in use, according to the first listed reference. No information on their operation is available.
13. No information available on these systems beyond what is listed.
14. Further information is available in the applicable weapons system student manuals which are unavailable to GE.

# SUBSYSTEM PARAMETER DATA LIST

HELICOPTER: YAM-64

Table: D7

SUBSYSTEM: Auxiliary Power Unit

Sheet No.: 1

PARAMETER NAME - INDICATOR LABEL	INDICATOR				OPERATING MODE	CONDITION	PARAMETER		REFERENCES (STUDENT MANUAL: EDT-3 TRNG CRSE)	NOTE # (SH 2)
	TYPE	RANGE	MARKINGS	UNITS			CONDITION TYPE -	DURATION		
Gas Producer Speed - APU Ng	Circular Dial (P)	0-120	(106-120)R	%	All	0- (100.5 ±5)	Normal - continuous	pp 5-7 & 16	1,5	
						(100.5 + 0.5 - 107 ±1)	Cautionary - transient			
						110%	Maximum - none specified			
FAIL APU	Caution Lgt (P)	--	Amber	--	APU SW START, then RUN	1. <60% rpm @ 20 seconds, or 2. >107 ±1% rpm, or 3. <90% rpm (see note), or 4. >1324° ±25°F EGT, or 5. <31 psi oil pressure for over 10 secs		pp 5-4, 16, 17 & 16-12 (PS14-110218) pp 8, 11, 12 & 17 (TM 55-1520-238) -10, pp 8-12 & 13	1,2,3, 6	
						Cautionary - none specified				
APU ON	Advisory Lgt (P)	--	Green	--					1,2,4, 7	

Table: D7 (Auxiliary Power Unit - Cont'd)

Sheet No.: 2

NOTES:

1. The terms "P" & "CPG" refer to the Pilot's and Copilot/Gunner's crew stations, respectively. In the case of indicator lights, the number of lights at the particular crew station precedes the crew station designation along with a semicolon.
2. TM 55-1520-238-10 is a preliminary Operator's Manual, dated 31 May 1979. Much of the data which describes specific parameter conditions in conjunction with operating modes is yet to be supplied following flight testing.
3. Sensor is a mechanical switch which has a closed (fault condition) resistance of 10 ohms maximum and an open resistance of 2 megohms minimum. The maximum voltage and current with the switch closed are 0.1 VDC and 5-7 milliamperes respectively, while the switch open values are 5 to 30 VDC (positive) and 25 microamperes respectively.
4. Light is activated by a 28 VDC signal from the sensing device to the caution/advisory panel. In the high state, the fault signal source output voltage is 16-30 VDC with load currents of 5 milliamperes to 10 milliamperes respectively. The rise time is from 1 to 20 microseconds. In the no fault case (low state) the output voltage is 0-0.5 VDC.
5. Sensor is most likely a tachometer generator. The (106-120)% range of Ng speeds is presumed marked red, since only black and white copies of the manual are available.
6. Note that the Operator's Manual, p 8-12, says APU shutdown is initiated for Ng overspeed of 110% yet the Student Manual says this occurs at  $107 \pm 1\%$ . The last figure was selected as the most probable threshold. Note that there is a discrepancy between the turn on thresholds shown in the first reference (pp 5-16 & 17 versus p 16-12). The last listed page indicates that light operation is linked only to oil pressure. That page also indicates a light turn off threshold of 40 psi increasing oil pressure and more than 95% rpm for over 10 seconds.
7. The light turn off threshold is  $107 \pm 1\%$  rpm or switch turnoff.

APPENDIX 2

FAULT/PARAMETER MA RIX

Parameters	Subsystem Parameter Data List Reference (Table #, Sheet #)	Sensor/Signal Availability (A-Analog, D-Discrete)	Single Parameter Faults Requiring Inputs as Indicated (See Appendix 2)	Multiple Parameter Faults												
				Eng 1 Flameout	Eng 2 Flameout	Eng 1 & 2 Flameout	Eng 1 Deep Trim	Eng 2 Deep Trim	Eng 1 N <sub>2</sub> Sensing Fail	Eng 2 N <sub>2</sub> Sensing Fail	Eng 1 Deep Trim	Eng 2 Deep Trim	Left, Main Fuel Cell Overpressure	Right, Main Fuel Cell Overpressure	Eng 1 Fuel Flow High	Eng 2 Fuel Flow High
1 Eng 1 Gas Producer (N <sub>1</sub> )	A1,1	A	1	X												
2 Eng 2 Gas Producer (N <sub>2</sub> )	A1,1	A	2													
3 Eng 1 PTIT	A1,1	A	3	X	X											
4 Eng 2 PTIT	A1,1	A	4	X	X											
5 Eng 1 Torque	A1,2	A	5	X	X											
6 Eng 2 Torque	A1,2	A	6	X	X											
7 Eng 1 Oil Pressure	A1,2	A	7	X	X											
8 Eng 2 Oil Pressure	A1,2	A	8		X											
9 Eng 1 Oil Temperature	A1,3	A	9													
10 Eng 2 Oil Temperature	A1,3	A	10													
11 Eng 1 Oil Level	A1,3	D	11													
12 Eng 2 Oil Level	A1,3	D	12													
13 Eng 1 Chip	A1,3	D	13													
14 Eng 2 Chip	A1,3	D	14													
15 Eng 1 Cond-Lever Phase	A1,3	D	15	X												
16 Eng 2 Cond-Lever Phase	A1,3	D	16		X											
17 Fuel Qty - Left, Fwd	A2,1	A	17													
18 Fuel Qty - Left, Main	A2,1	A/D	18													
19 Fuel Qty - Left, Aft	A2,1	A	19													
20 Fuel Qty - Rt, Fwd	A2,1	A	20													
21 Fuel Qty - Rt, Main	A2,1	A	21													
22 Fuel Qty - Rt, Aft	A2,1	A/D	22													
23 Eng 1 (Lt) Fuel Press	A1,1	D	23													
24 Eng 2 (Rt) Fuel Press	A2,1	D	24													
25 Fuel Press --Left, Fwd	A2,1	D	25													
26 Fuel Press Left, Aft	A2,1	D	26													
27 Fuel Press - Rt, Fwd	A2,1	D	27													
28 Fuel Press - Rt, Aft	A2,1	D	28													
29 Rotor RPM	A3,1	A	5,6,29													
30 Eng 1 Xmsn Oil Press	A3,1	A	30	X												
31 Eng 2 Xmsn Oil Press	A3,1	A	31		X											
32 Combining Xmsn Oil Press	A3,1	A	32													
33 Fwd Xmsn Oil Press	A3,1	A	33													
34 Aft Xmsn Oil Press	A3,1	A	34													
35 Eng 1 Xmsn Oil Temp	A3,2	A	35													
36 Eng 2 Xmsn Oil Temp	A3,2	A	36													
37 Combining Xmsn Oil Temp	A3,2	A	37													
38 Fwd Xmsn Oil Temp	A3,2	A	38													
39 Aft Xmsn Oil Temp	A3,2	A	39													
40 Combining Xmsn Chip	A3,2	D	40													



FAULT PARAMETER MATRIX (Cont'd) (Sheet 2 of 6)

Parameters	Subsystem Parameter Data List Reference (Table #, Sheet #)	Sensor/Signal Availability (A-Analog, D-Discrete)	Single Parameter Faults Requiring Inputs as Indicated (See Appendix 2)	Multiple Parameter Faults																		
				Eng 1 Flameout	Eng 2 Flameout	Eng 1 & 2 Flameout	Eng 1 Beep Trim	High Side Fall	Eng 2 Beep Trim	High Side Fall	Eng 1 N <sub>2</sub> Sensing Fail	Eng 2 N <sub>2</sub> Sensing Fail	Low Side Fall	Eng 1 Beep Trim	Low Side Fall	Eng 2 Beep Trim	Low Side Fall	Left, Main Fuel Cell Overpressure	Right, Main Fuel Cell Overpressure	Eng 1 Fuel Flow High	Eng 2 Fuel Flow High	No. 1 & 2 FLT Control Hyd Fail
41 Fwd Xasn Chip	A3,2	D	41																			
42 Aft Xasn Chip	A3,2	D	42																			
43 Aft Vert Thrust Brng Chip	A3,2	D	43																			
44 #1 Flt Ctrl Hyd Press	A4,1	A/D	44																			
45 #2 Flt Ctrl Hyd Press	A4,1	A/D	45																			
46 Utility Hyd Press	A4,1	A	46																			
47 #1 Generator Load	A5,1	A/D	49																			
48 #2 Generator Load	A5,1	A/D	50																			
49 #1 Rectifier Load	A5,1	A/D	51																			
50 #2 Rectifier Load	A5,1	A/D	52																			
51 AC Ext Power Status	A5,1	D	49-52																			
52 DC Ext Power Status	A5,2	D	49-52																			
53 Fwd Cyclic Trim Actuator Pos	A6,1	A	53																			
54 Aft Cyclic Trim Actuator Pos	A6,1	A	54																			
55 #1 SAS Status	A6,1	D	55																			
56 #2 SAS Status	A6,1	D	56																			
57 Heater Output Temp	A6,1	D	57																			
58 Rt Aft Lndg Gear Phase	A6,1	D	58																			
59 APU Turbine Speed	A7,1	A	83																			

Additional Required Inputs	New Sensor Required	Signal/Sensor Type (A-Analog, D-Discrete)	Single Parameter Faults Requiring Inputs as Indicated (See Appendix 2)	Multiple Parameter Faults													
				Eng 1 Flameout	Eng 2 Flameout	Eng 1 & 2 Flameout	Eng 1 Beep Trim High Side Fail	Eng 2 Beep Trim High Side Fail	Eng 1 N <sub>2</sub> Sensing Fail	Eng 2 N <sub>2</sub> Sensing Fail	Eng 1 Beep Trim Low Side Fail	Eng 2 Beep Trim Low Side Fail	Left, Main Fuel Cell Overpressure	Right, Main Fuel Cell Overpressure	Eng 1 Fuel Flow High	Eng 2 Fuel Flow High	No. 1 & 2 FLT Control Hyd Fail
1 Eng 1 Cond-Lever Pos(1)		D	1,29(3)	X	X			X									
2 Eng 2 Cond-Lever Pos(1)		D	2,29(3)		X					X							
3 Eng 1 Ignition Sw State		D	3														
4 Eng 2 Ignition Sw State		D	4														
5 Eng 1 Start Button State		D	3														
6 Eng 2 Start Button State		D	4														
7 Eng 1 Beep Trim Sw State		D						X	X								
8 Eng 1 & 2 Beep Trim Sw State		D						X	X								
9 Eng 1 Norm Trim Selector Sw		D						X	X								
10 Eng 2 Norm Trim Selector Sw		D						X	X								
11 Fuel System X-Feed Valve Pos		D						X	X								
12 Utility Hyd Temperature	X	D	47							X							
13 Eng 1 N <sub>2</sub> Control Actuator Signal		A		X				X									
14 Eng 2 N <sub>2</sub> Control Actuator Signal		A			X					X							
15 Eng 1 Beep Trim Ref Signal		A						X									
16 Eng 2 Beep Trim Ref Signal		A						X	X								
17 Thrust Control Rod Pos		A						X	X								
18 APU Accumulator Press	X	A	48														
19 Outside Air Temp	X	A	3,4,9,10,53,54														
20 Pressure Altitude	X	A	23,24,53,54														
21 Indicated Airspeed	X	A	54														
22 Gross Weight(2)	X	A	53,54														
System Status																	
1 Eng 1 Flamed Out		D	6														
2 Eng 2 Flamed Out		D	5														
3 Eng 1 & 2 Flamed Out		D	29(3)														

Parameters	Subsystem Parameter Data List Reference (Table #, Sheet #)	Sensor/Signal Availability (A-Analog, D-Discrete)	Multiple Parameter Faults					
			No. 1 & 2 SAS Fail	No. 1 & 2 Generators Fail	No. 1 & 2 Rectifiers Fail	AC Bus X-Tie Fail	DC Bus X-Tie Fail	AGB Quill Shaft Fail
1 Eng 1 Gas Producer (N1)	A1,1	A						
2 Eng 2 Gas Producer (N2)	A1,1	A						
3 Eng 1 PTIT	A1,1	A						
4 Eng 2 PTIT	A1,1	A						
5 Eng 1 Torque	A1,2	A						
6 Eng 2 Torque	A1,2	A						
7 Eng 1 Oil Pressure	A1,2	A						
8 Eng 2 Oil Pressure	A1,2	A						
9 Eng 1 Oil Temperature	A1,3	A						
10 Eng 2 Oil Temperature	A1,3	A						
11 Eng 1 Oil Level	A1,3	D						
12 Eng 2 Oil Level	A1,3	D						
13 Eng 1 Chip	A1,3	D						
14 Eng 2 Chip	A1,3	D						
15 Eng 1 Cond-Lever Position	A1,3	D						
16 Eng 2 Cond-Lever Position	A1,3	D						
17 Fuel Qty - Left, Fwd	A2,1	A						
18 Fuel Qty - Left, Main	A2,1	A/D						
19 Fuel Qty - Left, Aft	A2,1	A						
20 Fuel Qty - Rt, Fwd	A2,1	A						
21 Fuel Qty - Rt, Main	A2,1	A/D						
22 Fuel Qty - Rt, Aft	A2,1	A						
23 Eng 1 (Lt) Fuel Press	A1,1	D						
24 Eng 2 (Rt) Fuel Press	A2,1	D						
25 Fuel Press - Left, Fwd	A2,1	D						
26 Fuel Press Left, Aft	A2,1	D						
27 Fuel Press - Rt, Fwd	A2,1	D						
28 Fuel Press - Rt, Aft	A2,1	D						
29 Rotor RPM	A3,1	A						
30 Eng 1 Xmsn Oil Press	A3,1	A						
31 Eng 2 Xmsn Oil Press	A3,1	A						
32 Combining Xmsn Oil Press	A3,1	A						
33 Fwd Xmsn Oil Press	A3,1	A						
34 Aft Xmsn Oil Press	A3,1	A						
35 Eng 1 Xmsn Oil Temp	A3,2	A						
36 Eng 2 Xmsn Oil Temp	A3,2	A						
37 Combining Xmsn Oil Temp	A3,2	A						
38 Fwd Xmsn Oil Temp	A3,2	A						
39 Aft Xmsn Oil Temp	A3,2	A						
40 Combining Xmsn Chip	A3,2	D						
								X

Parameters	Subsystem Parameter Data List Reference (Table #, Sheet #)	Sensor/Signal Availability (A-Analog, D-Discrete)	Multiple Parameter Faults					
41 Fwd Xean Chip	A3.2	D	No. 1 & 2 SAS Fail	No 1 & 2 Generators Fail	No 1 & 2 Rectifiers Fail	AC Bus X-Tie Fail	DC Bus X-Tie Fail	AGB Quill Shaft Fail
42 Aft Xean Chip	A3.2	D						
43 Aft Vert Thrust Brng Chip	A3.2	D						
44 #1 Flt Ctrl Hyd Press	A4.1	A/D						
45 #2 Flt Ctrl Hyd Press	A4.1	A/D						
46 Utility Hyd Press	A4.1	A						
47 #1 Generator Load	A5.1	A						
48 #2 Generator Load	A5.1	A/D						
49 #1 Rectifier Load	A5.1	A/D						
50 #2 Rectifier Load	A5.1	A/D						
51 AC Ext Power Status	A5.1	D						
52 DC Ext Power Status	A5.2	D						
53 Fwd Cyclic Trim Actuator Pos	A6.1	A						
54 Aft Cyclic Trim Actuator Pos	A6.1	A						
55 #1 SAS Status	A6.1	D						
56 #2 SAS Status	A6.1	D						
57 Heater Output Temp	A6.1	D						
58 Rt Aft Lndg Gear Phase	A6.1	D						
59 APU Turbine Speed	A7.1	A						

Additional Required Inputs	New Sensor Required	Signal/Sensor Type (A-Analog, D-Discrete)	Multiple Parameter Faults				
1 Eng 1 Cond-Lever Pos(1) 2 Eng 2 Cond-Lever Pos(1) 3 Eng 1 Ignition Sw State 4 Eng 2 Ignition Sw State 5 Eng 1 Start Button State 6 Eng 2 Start Button State 7 Eng 1 Beep Trim Sw State 8 Eng 1 & 2 Beep Trim Sw State 9 Eng 1 Norm Trim Selector Sw 10 Eng 2 Norm Trim Selector Sw 11 Fuel System X-Feed Valve Pos 12 Utility Hyd Temperature 13 Eng 1 N <sub>2</sub> Control Actuator Signal 14 Eng 2 N <sub>2</sub> Control Actuator Signal 15 Eng 1 Beep Trim Ref Signal 16 Eng 2 Beep Trim Ref Signal 17 Thrust Control Rod Pos 18 AM Accumulator Press 19 Outside Air Temp 20 Pressure Altitude 21 Indicated Airspeed 22 Gross Weight(2) 23 System Status 1 Eng 1 Flamed Out 2 Eng 2 Flamed Out 3 Eng 1 & 2 Flamed Out	X  <						

## NOTES

1. Engine Condition Lever positions would be a three state discrete - STOP, GROUND and FLY.
2. Gross Weight could also be entered manually via key pad.
3. Note that fault 29, Rotor RPM Limit/Rate, has operating modes which depend not only on Engine Condition Lever positions, but also on the phase of flight. Thus, when the aircraft is on the ground, minimum continuous rpm is 214. If in flight and either both engines are flamed out or both condition levers are at GROUND or STOP the autorotation limits apply.

# APPENDIX 3 FAULT/ADVISORY LIST

No.	Fault Description	No.	Fault Description
1	Eng 1 N1 Limit	45	#2 Flight Control Hydraulic Press Limit/Rate
2	Eng 2 N1 Limit	46	Utility Hydraulic Press Limit/Rate
3	Eng 1 P/T Limit/Rate	47	Utility Hydraulic Temp Limit
4	Eng 2 P/T Limit/Rate	48	APU Accumulator Press Limit/Rate
5	Eng 1 Torque Limit	49	#1 Generator Load Limit
6	Eng 2 Torque Limit	50	#2 Generator Load Limit
7	Eng 1 Oil Press Limit/Rate	51	#1 Rectifier Load Limit
8	Eng 2 Oil Press Limit/Rate	52	#2 Rectifier Load Limit
9	Eng 1 Oil Temp Limit/Rate	53	Fwd Cyclic Trim Actuator Position Limit
10	Eng 2 Oil Temp Limit/Rate	54	Aft Cyclic Trim Actuator Position Limit
11	Eng 1 Oil Level Limit	55	#1 SAS OFF
12	Eng 2 Oil Level Limit	56	#2 SAS OFF
13	Eng 1 Chip Detected	57	Heater Output Temp Limit
14	Eng 2 Chip Detected	58	Rt. Aft Landing Gear Phase Limit
15	Eng 1 Condition Lever Out of Detent		Multiple Parameter Faults
16	Eng 2 Condition Lever Out of Detent		
17	Fuel Qty - Left, Fwd Limit/Rate (includes overpressure)	59	Eng 1 Flameout
18	Fuel Qty - Left, Main Limit/Rate	60	Eng 2 Flameout
19	Fuel Qty - Left, Aft Limit/Rate (includes overpressure)	61	Eng 1 & 2 Flameout
20	Fuel Qty - Right, Fwd Limit/Rate (includes overpressure)	62	Eng 1 Beep Trim High Side Fail
21	Fuel Qty - Right, Main Limit/Rate	63	Eng 2 Beep Trim High Side Fail
22	Fuel Qty - Right, Aft Limit/Rate (includes overpressure)	64	Eng 1 N2 Sensing Fail
23	Eng 1 Fuel Pressure Limit	65	Eng 2 N2 Sensing Fail
24	Eng 2 Fuel Pressure Limit	66	Eng 1 Beep Trim Low Side Fail
25	Fuel Press - Left, Fwd Limit	67	Eng 2 Beep Trim Low Side Fail
26	Fuel Press - Left, Aft Limit	68	Left, Main Fuel Cell Overpressure
27	Fuel Press - Right, Fwd Limit	69	Right, Main Fuel Cell Overpressure
28	Fuel Press - Right, Aft Limit	70	No. 1 & 2 F/T Control Hyd Fail
29	Rotor RPM Limit	71	No. 1 & 2 Generators Fail
30	Eng 1 XMSN Oil Press Limit/Rate	72	No. 1 & 2 Rectifiers Fail
31	Eng 2 XMSN Oil Press Limit/Rate	73	No. 1 & 2 SAS Fail
32	Combining XMSN Oil Press Limit/Rate	74	Eng 1 Fuel Flow High
33	Fwd XMSN Oil Press Limit/Rate	75	Eng 2 Fuel Flow High
34	Aft XMSN Oil Press Limit/Rate	76	AC Bus X-Tie Fail
35	Eng 1 XMSN Oil Temp Limit/Rate	77	DC Bus X-Tie Fail
36	Eng 2 XMSN Oil Temp Limit/Rate	78	AGB Quill Shaft Fail
37	Combining XMSN Oil Temp Limit/Rate		Advisory List
38	Fwd XMSN Oil Temp Limit/Rate	79	AC External Power
39	Aft XMSN Oil Temp Limit/Rate	80	DC External Power
40	Combining XMSN Chip Detection	81	Parking Brake Status
41	Fwd XMSN Chip Detected	82	Cargo Hook Status
42	Aft XMSN Chip Detected	83	APU Status
43	Aft Vertical Thrust Bearing Chip Detected		
44	#1 Flight Control Hydraulic Press Limit/Rate		

APPENDIX 4

ROUTINE CHECKLISTS

ROUTINE CHECKLISTS (Sheet 1 of 12)

STARTING ENGINES

Item	Procedure Description	Pilot Response	EMMADS Actions
1	*CHECK INTERPHONE	Acknowledge	Initialize by relegendable switch. Place a box around item 1.
2	*CHECK MAIN FUEL & X-FEED VALVE LIGHTS (FLT ENG)	Acknowledge	Detect acknowledge, change response to a "/", move box next item.
3	*POST FIRE GUARD	Acknowledge	Same as above.
4	*CHECK APU LIGHTS (PRESS)	Acknowledge	Same as above.
5	*APU SWITCH TO APU, CHECK LOW OIL PRESS LIGHT OUT, HIGH EXH TEMP AND OVSP LIGHTS ON	Acknowledge	Same as above.
6	*GND-APU-AGB TO START (HOLD)	Acknowledge	Same as above.
7	*APU SWITCH TO START (RELEASE AT 90%)	Accomplish	Sense APU ON condition (APU speed is 98-106%) and place that message in Response column. Begin a 30 second countdown for hydraulic pressures. When fault condition 45 is sensed as cleared, indicate item 8 is ready to be accomplished by boxing both the procedure description and response. Also enable faults 34 and 39 when values reach lower normal limits.
8	*GND-APU-AGB SWITCH TO	RELEASE	Sense switch position if possible and remove box around response. Do not move box to next item until 30 second countdown is halted. The countdown should halt when faults 44-46 and 69 are all cleared. At this point these faults should be enabled. If the countdown is completed, all these faults should be enabled. When the faults are cleared box around item 9, including the response.
9	GENERATOR #1 CONTROL SWITCH TO	ON	Sense the switch position and enable fault 49. If no DC Ext. Power is connected (sense advisory condition) enable fault 51. If no faults detected, move box to item 10.
10	GENERATOR #2 CONTROL SWITCH TO	ON	Same as above, but substitute faults 50 and 52 for 49 and 51. If no DC Ext. Power is connected, also enable faults 76 and 77.
11	DISCONNECT EXTERNAL POWER	Acknowledge	If only AC Ext. Power was on aircraft, sense the acknowledge and move box to next item. If DC Ext Power was also sensed on, wait until that advisory is cleared, enable faults 76 and 77, sense acknowledge and move box to next step.
12	POSITION FLIGHT CONTROLS	Acknowledge	Same as for item 1.
13	AVIONICS ON AS REQUIRED	Acknowledge	Same as for item 1.

\* EMMADS can only display these items if AC external power is supplied, unless the APU is started first. If when EMMADS powers up it detects the APU operating, selection of this checklist causes a jump to item 9, enabling faults 34, 39, 44-46 & 69)



ROUTINE CHECKLISTS (Sheet 2 of 12)  
(Continued)

STARTING ENGINES			EMMADS Actions
Item	Procedure Description	Pilot Response	
14	SET POSITION LIGHTS AS REQUIRED (ON-DAY; OFF-NIGHT)	Acknowledge	Same as item 10.
15	TURN ON ANTI-COLL LTS SWITCH AND CHECK	Acknowledge	Same as above.
16	CHECK SEARCH LIGHT FOR PROPER OPERATION	Acknowledge	Same as above.
17	RESET PARKING BRAKE	Accomplish	If fault (advisory) 81 changes state ending with an active condition, place an "ON" in the Response section. Move box to next item.
18	CHECK CRUISE GUIDE INDICATOR	Acknowledge	Same as item 13.
19	SET ALTIMETER TO FIELD ELEVATION	Acknowledge	Same as above.
20	TEST FIRE DETECTOR	Acknowledge	Same as above.
21	CHECK AND SET STICK POSITIONER	Acknowledge	Same as in item 1.
22	TURN OFF HEATER	Acknowledge	Same as above, plus begin a 2 minute countdown. If item 28 is completed before the end of this countdown, blank the checklist and display the remaining time plus the message "HEATER PURGING - PLEASE STANDBY". Return to checklist at completion of countdown and move box to next item.
23	CHECK ROTOR BLADE POSITION	Acknowledge	Same as item 18.
24	CHECK FLIGHT CONTROLS WITH HYD BST SWITCH AT BOTH	Acknowledge	Same as above.
25	CHECK FLIGHT CONTROLS WITH HYD BST SWITCH AT NO. 1 ON.	Accomplish	Since fault 44 is enabled, the checklist will be cleared and the hydraulic subsystem will be displayed with an appropriate message. When the fault clears, place a "/" in the Response column. Move box to next item.
26	CHECK FLIGHT CONTROLS WITH HYD BST SWITCH AT NO. 2 ON.	Accomplish	Similar to item above.
27	CHECK AVIONICS	Acknowledge	Same as item 1.
28	NO 1 & 2 ENG BEEP TRIM SWITCH	DECREASE	Begin 8 second countdown when switch position is sensed. If the beep reference signal slopes are not zero when countdown is complete, blank screen and display "ENG 1(2) BEEP STILL DECREASING AFTER 8 SECONDS" with the proper engine number selected. If slopes at zero before countdown is complete, stop countdown, change response to "RELEASE". When switch is released, move box to next item.
29	CLEAR ENG 1 FOR START	Acknowledge	Same as item 1.

ROUTINE CHECKLISTS (Sheet 3 of 12)  
(Continued)

STARTING ENGINES

Item	Procedure Description	Pilot Response	ENMADS Actions
30	LEFT MAIN FUEL PUMP SWITCHES TO	ON	Monitor fault 23. When the fault is de-activated (main fuel pressure is up) move box to next item.
31	CROSS FEED FUEL VALVE SWITCH TO	OPEN	Monitor fault 24. When the fault is de-activated, move box to next item.
32	ENG 1 CONDITION LEVER TO	STOP	Sense lever position, move box to next item.
33	ENG 1 START FUEL SWITCH TO	OPEN	Sense switch position, move box to next item.
34	ENG 1 IGNITION SWITCH TO	ON	Same as above.
35	ENG 1 START BUTTON	PRESS & HOLD	<p>(Note: It is likely that a display of N<sub>1</sub> &amp; PTIT may have to be included during both engine starts. This would come up when the START button is pressed and last until "ENG 1/2 RUNNING" is displayed.) Sense switch position and disable faults 50, 52, 76 and 77 unless APU is not running. Display "LOAD FAULT" and electrical subsystem if any of the disabled faults are not active. If items 28-34 have not been completed, blank the screen and display "RELEASE START BUTTON - CHECKLIST ITEMS MISSED". When button is released, return to checklist display boxing first incompleted item. Allow all items remaining to be completed in sequence. Begin a 45 second countdown for engine acceleration, and monitor N<sub>1</sub>. When N<sub>1</sub> = 10%, change response of item 32 from "STOP" to "GROUND" and flash a box around the response only. Sense lever position at GROUND and remove item 32 box. Also monitor PTIT, TORQUE, Oil Press. and Temp. for Eng 1 plus all Xmsn Oil Pressures and temperatures. As each parameter reaches the lower end of its normal limit, enable the corresponding faults (1, 3, 5, 7, 9, 30, 32, 33, 35, 37 and 38). When PTIT reaches 450°C or N<sub>1</sub> reaches 45%, change the response of item 33 from "OPEN" to "CLOSE" and flash a box around the response only. Do the same thing for item 34 (only when N<sub>1</sub> reaches 45%) changing the response from "ON" to "OFF", and for item 35, changing the response from "PRESS &amp; HOLD" to "RELEASE". Remove flashing boxes from these items when the desired switch position(s) are attained. If N<sub>1</sub>, PTIT and engine oil press. and temp. faults are all enabled before 45 second countdown is complete, discontinue countdown and remove the box around item 35. If not, enable any remaining faults at the end of the countdown, and display as required. When the response of item 35 is changed to "RELEASE", begin a 3 minute countdown for starting Eng 2. If Eng 2 START button is not pressed after 2 minutes, blank screen and display "2 MINUTES SINCE ENGINE START - PLEASE ACKNOWLEDGE AND START SECOND ENGINE". An acknowledge returns the display to the checklist. After item 35 box is removed enable fault 59 and display "ENG 1 RUNNING" after item 35. Move box to item 36.</p>
36	CLEAR ENG 2 FOR START	Acknowledge	Sense the acknowledge and proceed as in item 1.

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ROUTINE CHECKLISTS (Sheet 4 of 12)  
(Continued)

STARTING ENGINES

Item	Procedure Description	Pilot Response	ENMADS Actions
37	ENG 2 CONDITION LEVER TO	STOP	Same as item 32, going to item 38 instead of 33.
38	ENG 2 START FUEL SWITCH TO	OPEN	Same as item 33, going to item 39 instead of 34.
39	ENG 2 IGNITION SWITCH TO	ON	Same as item 34, going to item 40 instead of item 35.
40	ENG 2 START BUTTON	PRESS & HOLD	Same as for item 35. If items 38-39 have not been accomplished, follow the guidelines given for item 35. If no items are missed, again follow procedures similar to those in item 35. For fault enabling, disregard the XMSN Oil Press. and Temp. faults since these are already enabled during the previous engine start. Substitute faults 2, 4, 6, 8, 10, 31 and 36 for faults 1, 3, 5, 7, 9, 30 and 35 in item 35. When normal limits are reached, enable faults 60 and 61 at the points corresponding to enabling fault 59 in item 35. Display "ENG 2 RUNNING" after item 40 when box moved to item 41. Also re-enable faults 50, 52, 76 and 77 if applicable.
41	ENG CONDITION LEVERS TO	FLIGHT	Sense lever positions at "FLIGHT", move box to next item and enable fault 29 plus any of faults 30-33 and 35-38 not already enabled.
42	ADJUST ENG BEEP TO 245 ROTOR RPM AND MATCHED TORQUE		Monitor rotor rpm and Eng 1 and 2 torque (whenever engine torques are matched, symbology on torque indicator should be modified in same way to indicate this match or "lock"). When both conditions are met handle response symbol and flash next item. Enable faults 62-67. Move box to next item.
43	APU SWITCH TO	STOP	Sense switch position and remove box. Wait for acknowledge and clear display. Enable all faults that were supposed to be enabled in this checklist, as previously described.

ROUTINE CHECKLISTS (Sheet 5 of 12)  
(Continued)

ENGINE GROUND OPERATION

Item	Procedure Description	Pilot Response	EMWADS Actions
			Initialize checklist with acknowledge switch. Draw a box around item 1.
1	SET VGI SWITCHES AS REQUIRED	Acknowledge	Same as item 1 of preceding checklist.
2	GEN 1 SWITCH TO	OFF	Since faults 49, 51, 76 and 77 are enabled, the response is automatic. When the fault(s) clear, return to the checklist. Change "OFF" to "ON", and move box to next item.
3	GEN 2 SWITCH TO	OFF	Same as above (faults 50, 52 vs faults 49 and 51). When fault(s) cleared, maintain display and place item 4 in the position where the message capsule normally is, with a box around it. Enable faults 71 and 72.
4	CHECK PITOT HEAT	Acknowledge	When the acknowledge is sensed, clear the electrical subsystem display and replace it with that of the engine subsystem. Display item 5 with a box around it where the message capsule normally appears.
5	CHECK ANTI-ICING	Acknowledge	Sense the acknowledge and return to the checklist display. Items 4 and 5 should have a "/" after them in the Response column.
6	CLOSE FUEL X-FEED VALVE	Acknowledge	Sense fault 24 active, move box to next item and display a "/" in the Response column.
7	ALL FUEL BOOST PUMP SWITCHES TO	OFF	Sense faults 23-28 active and move box to next item.
8	LEFT APT AUX FUEL PUMP SWITCH TO	ON	Sense faults 23 and 26 not active, change response to "OFF". Sense faults 23 and 26 active. Move box to next item.
9	LEFT MAIN FUEL PUMP SWITCHES TO	ON	Same as above but sense only fault 23.
10	LEFT PWD AUX FUEL PUMP SWITCH TO	ON	Sense faults 23 and 25 not active, handle as in item 8 above.
11	RIGHT PWD AUX FUEL PUMP SWITCH TO	ON	Same as item 8 but use faults 24 and 27 respectively.
12	RIGHT MAIN FUEL PUMP SWITCHES TO	ON	Same as item 9 using fault 24.
13	RIGHT APT AUX FUEL PUMP SWITCH TO	ON	Same as item 10 using faults 24 and 28 respectively.
14	TURN ON ALL BOOST PUMPS	Acknowledge	Sense acknowledge and enable faults 23-28, 68 and 69.
15	CHECK FLIGHT INSTRUMENTS	Acknowledge	Same as in item 1.

ROUTINE CHECKLISTS (Sheet 6 of 12)  
(Continued)

ENGINE GROUND OPERATION

Item	Procedure Description	Pilot Response	EMMADS Actions
16	CHECK ENG 1 EMERGENCY TRIM	Acknowledge	As the check is currently accomplished, simply sense acknowledge change "1" to "2" in Procedure Description, sense acknowledge a second time and go to next item. However, must leave open the possibility for testing the Emergency Beep Trim Display mode as well (partial display using N <sub>1</sub> and PRIT).
17	PERFORME HIT CHECK	Acknowledge	Sense acknowledge, remove box and place a "/" in response column. Enable all faults listed in past two checklists if not already enabled. Sense second acknowledge and blank display.

ROUTINE CHECKLISTS (Sheet 7 of 12)  
(Continued)

BEFORE TAKEOFF/LANDING

Item	Procedure Description	Pilot Response	EMMADS Actions
1	SET PARKING BRAKE AS REQUIRED	Acknowledge	Initialize by sensing acknowledge or relegendable switch. Enable fault 78 unless this check preceded by the HOVER CHECK. Put box around item 1.
2	LOCK AFT WHEEL	Acknowledge	Sense acknowledge and move box to next item. Place a "/" in response column.
3	ENTER SAS RELEASE SWITCH TO	ENGAGE	Same as above.
4	SET PSAS AS REQUIRED	Acknowledge	When fault 73 sensed as active, enable faults 55, 56 and 73 unless already enabled. Move box to item 4. Enable faults 53 and 54.
5	SET CYCLIC TRIM	Acknowledge	Same as item 1.
6	SET TRANSPONDER AS REQUIRED	Acknowledge	Same as item 1.
7	CHECK CREW, PAX AND EQUIPMENT	Acknowledge	Same as item 1.
8	SET SEARCH LIGHTS AND/OR LANDING LIGHTS AS REQUIRED	Acknowledge	Same as item 1. If this check preceded by HOVER CHECK or ENGINE GROUND OPERATION CHECK wait for CRUISE CHECK or HOVER CHECK respectively. If preceded by CRUISE CHECK, disable faults 74 and 75 and wait for HOVER CHECK. Sense second acknowledge and blank screen.

ROUTINE CHECKLISTS (Sheet 8 of 12)  
(Continued)

HOVER CHECK

Item	Procedure Description	Pilot Response	EMMADS Actions
1	CHECK FLIGHT CONTROLS	Acknowledge	Initialize by sensing acknowledge or relegendable switch and place box around item 1. (Reaffirm faults from previous checklists all enabled.) Sense acknowledge, move box to next item and place a "/" in response column.
2	CHECK FLIGHT INSTRUMENTS	Acknowledge	Same as above.
3	CHECK POWER MARGIN	Acknowledge	Same as above.
4	SAS CHECKED?	Acknowledge	If acknowledge sensed before 15 second countdown completed, remove box, blank remainder of checklist and place a "/" in response column. Sense second acknowledge and blank display. If countdown completed before acknowledge sensed, move box to item 5.
5	TURN OFF PITCH STAB AUG SWITCH	Acknowledge	Same as item 1.
6	CHECK SAS WITH SWITCH AT	NO.1 ON	Since fault 56 is enabled, fault will be displayed in normal manner. If acknowledge sensed, clear display back to checklist and change "1" to "2" in response. When switch position is changed, fault 55 will be detected. Follow same procedure. When both faults are cleared remove box and place a "/" in the response column. Sense second acknowledge and blank display.



ROUTINE CHECKLISTS (Sheet 9 of 12)  
(Continued)

CRUISE CHECK				
Item	Procedure Description	Pilot Response	EMMADS Actions	
			Initialize by sensing acknowledge or relegendable switch. Place a box around item 1.	
1	SET PITCH STAB AUG SWITCH AS REQUIRED	Acknowledge	Sense acknowledge, move box to next item.	
2	CHECK RAMP AREA	Acknowledge	Begin 30 minute countdown when acknowledge sensed. At end of countdown, reinitialize this checkout, unless a BEFORE LANDING CHECK occurs first, which stops the countdown. Move box to next item. Start 10 second countdown.	
3	SET FUEL FLOW BASELINE (provisional checklist item)	Acknowledge (YES)	If acknowledge is sensed before end of 10 second countdown, sense average fuel consumption over next 15 minutes and use as a baseline for faults 74 and 75. Then enable these faults, unless already enabled and remove box from item. Place a "✓" in the response column. Action is the same if no acknowledge sensed before countdown ends, except no baseline is set. Sense second acknowledge and blank screen.	

ROUTINE CHECKLISTS (Sheet 10 of 12)  
(Continued)

AFTER LANDING		EMMADS Actions	
Item	Procedure Description	Pilot Response	
1	SET EMERG SAS REL SWITCH TO DESIRED POSITION	Acknowledge	Initialized by a relegendable switch. Place box around item 1. Since SAS faults are enabled, if EMERG SAS REL switch activated, display faults normally. When acknowledge sensed, clear back to checklist, display a "/" in Response column, move box to item 2.
2	SET APT WHEELS SWIVEL SWITCH AS DESIRED	Acknowledge	Sense acknowledge, move box to next item, place a "/" in response column.
3	SET SEARCH LIGHTS AS DESIRED	Acknowledge	Same as above.
4	SET TRANSPONDER AS REQUIRED	Acknowledge	Sense acknowledge, remove box, place a "/" in response column. Sense second acknowledge and clear display.

ROUTINE CHECKLISTS (Sheet 11 of 12)  
(Continued)

ENGINE SHUTDOWN

Item	Procedure Description	Pilot Response	ENMADS Actions
1	LOCK AFT WHEELS SWIVEL	Acknowledge	Initialize by sensing releasable switch or acknowledge. Disable fault. (Advisory) 83. Draw box around item 1.
2	SET PARKING BRAKE AS REQUIRED	Acknowledge	Sense acknowledge, move box to next item, place a "✓" in response column.
3	TURN OFF HEATING SWITCHES	Acknowledge	Same as above.
4	TURN OFF ANTI-ICE SWITCHES	Acknowledge	Same as above.
5	DISARM EMERG EXIT LIGHTS	Acknowledge	Same as above.
6	SET FLIGHT CONTROLS	Acknowledge	Same as above.
7	EMERG SAS RELEASE SWITCH TO	RELEASE	Since fault 73 is enabled, the acknowledge for the fault is sensed before display will return to the checklist. Disable faults 55, 56 and 73. Move box to next item.
8	SET RAMP AS REQUIRED	Acknowledge	Same as item 1.
9	CHOCK WHEELS	Acknowledge	Same as above.
10	PTIT (TGT) RATE IS BEING CHECKED	WAIT	Monitor this parameter on both engines. When time rate of change is neither positive nor greater than 10°C/minute (based on current instrument resolution and experience) display "STABLE" instead of "BEING CHECKED" and "Acknowledge" instead of "WAIT". Proceed as in item 1.
11	POST FIREGUARD	Acknowledge	Same as item 1.
12	ENG 2 CONDITION LEVER TO	GROUND	Sense engine condition lever position. Monitor PTIT on engine #2 for negative slope. When slope goes to zero and/or begins to go positive, change response to "STOP". Sense lever position and move box to next item. (Continue to monitor for fault 4 until power down. All related Eng. faults, i.e., 2, 4, 6, 8, 10 and 31 should be detected when Eng. stopped - acknowledge brings back checklist. Eng. flameout will not be detected.)
13	ENG 2 FUEL PUMP SWITCHES TO	OFF	Faults 24, 27 and 28 should be detected. When acknowledged, return to checklist. Move box to next item.
14	BEEP (1 & 2) TO	235	When rotor rpm stable at 235 for 5 seconds, move box to next item.
15	CHECK APU LIGHTS (APU)	Acknowledge	Same as item 1.

ROUTINE CHECKLISTS (Sheet 12 of 12)  
(Continued)

ENGINE SHUTDOWN

Item	Procedure Description	Pilot Response	ENMADS Actions
16	APU SWITCH TO APU. CHECK LOW OIL PRESS LIGHT OUT, HIGH EXH TEMP AND OVSP LIGHTS ON	Acknowledge	Same as item 1.
17	APU SWITCH TO START (RELEASE AT 90%)	Accomplish	Sense APU ON (fault/advisory 83) and place that message in Response column. Move box to next item.
18	BEEP (1 & 2) SWITCH TO	DECREASE	Same as item 28 in STARTING ENGINES CHECKLIST. Move box to next item.
19	ENG 1 CONDITION LEVER TO	GROUND	Same as item 12 (substitute faults 1, 3, 5, 7, 9 and 30 for 2, 4, 6, 8, 10 and 31). Also may detect faults 24 and 32-34 rotors wind down. Move box to next item.
20	ENG 1 FUEL PUMP SWITCHES TO	OFF	Same as item 13, substitute faults 23, 25 and 26 for 24, 27 and 28 respectively. Move box to next item.
21	TURN OFF AVIONICS	Acknowledge	Same as item 1.
22	GENERATOR CONTROL SWITCHES TO	OFF	Faults 49-52 and 71 and 72 should be detected and displayed. Faults 73 or 76 should not appear. When faults are cleared go to next item if PTIT stability conditions in items 12 and 19 are met. Otherwise display engine parameters. (If faults 3 or 4 are tripped due to rising PTIT, engine parameters will come up on display.) Move box to next item.
23	TURN OFF LIGHT SWITCHES	Acknowledge	Sense acknowledge and Rotor rpm at zero, then proceed as in item 1.
24	APU SWITCH TO	STOP	ENMADS will power down. (Also expect faults 34, 44-46, 70 and 78.)*

\*Note: If fault 78 triggers an automatic APU start, must disable fault 78 before item 24 is accomplished and verify it is disabled.

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